Modelling V_{S30} in New Zealand Using Field Measurements, Proxy Variables, and Geophysical Methods

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Abstract

V_{S30}, the time-averaged 30-metre depth shear wave velocity (V_S) for vertically-propagating seismic shear waves, is among the most common parameters required for characterising sites in the context of geotechnical earthquake engineering. Direct measurement of V_{S30} requires invasive testing employing a geotechnical sounding (either drilled borehole or a pushed sCPT [seismic cone penetration test]). In recent years the use of indirect measurements (most commonly employing surface waves, generated and measured at the ground surface) has come into common practice for assessing V_{S30}. Surface wave based methods require no soundings and are thus less expensive than direct measurement, but are also subject to caveats associated with the inherently inferential nature of surface wave data interpretation.

Regardless of the approach taken, obtaining high-quality V_{S30} measurements in the field entails deployment of specialised equipment and personnel. There are many situations where it is appealing to obtain V_{S30} estimates more cheaply by means of statistical or geophysical inference. These include preliminary "desktop studies" performed by engineers in the very early phases of project planning (when field budgets are low and precision is of relatively less importance than the overall scope of potential project challenges), zoning for residential building codes (when site-specific V_{S30} measurements are not economical), and ground motion simulation research (when a geographically continuous V_{S30} estimate is needed for applying simple empirical site amplification functions across large regions). In these and other situations, there is a need for V_{S30} estimates that are less expensive to obtain than field measurements, even at the expense of higher uncertainty. This thesis comprises two distinct approaches to addressing this need. The first entails using continuously-available spatial proxy variables (geology and terrain) to generate a statistically robust V_{S30} model in map form with values available across the whole of New Zealand. The second is a geophysical approach to estimating V_{S30} at strong motion stations using weak earthquake recordings.

In the first half of the thesis, a V_{S30} model is developed for New Zealand as a weighted combination of a geology-based and a terrain-based model. The

model consists of two maps at 100-metre grid resolution, one encoded with a V_{S30} estimate and the other with uncertainty quantified as lognormal standard deviation (σ). A Bayesian updating process allows local V_{S30} measurements to control model estimates where data exist, and uses model estimates developed for other parts of the world where local data are sparse or nonexistent. Geostatistical interpolation is performed on the geology- and terrain-based models using local V_{S30} measurements to constrain the model in the vicinity of data. Conventional regression kriging is compared with a flexible multivariate normal (MVN) approach that allows for arbitrary assumptions regarding measurement uncertainty at each data location. A modification to the covariance structure in the MVN application allows for more realistic estimates by reducing undesirable extrapolation across geologic boundaries. The results of kriging and MVN approaches are compared. The geology- and terrain-based MVN models are combined to produce a final model suitable for engineering applications. Validation is performed by comparing the model predictions with the worldwide slope-based V_{S30} model developed by Allen and Wald (2009).

In the second half of the thesis, V_{S30} is estimated at select New Zealand strong motion stations (SMS) using a novel geophysical method relying on many recordings of weak earthquakes. SMS with field V_{S30} measurements were selected so that validation could be performed. The approach follows a number of recent studies that have used the continuum mechanical solution for the arrival of a P-wave at the surface of an elastic half-space to estimate shear wave velocity V_S near the surface using small earthquake recordings, and thence (via empirical correlations) V_{S30}. The approach requires as inputs the ratio of the radial and vertical components of ground velocity ($\frac{\dot{U}_R}{\dot{U}_Z}$) during the first P-wave arrival, and the ray parameter p. The latter is estimated using a regional-scale velocity model simplified to a two-layer, one-dimensional profile, and finding the location of refraction that minimizes travel time for the first arrival. In the present study the so-called "P-wave method" is applied to strong motion stations in New Zealand with V_{S30} measurements.

Since many stations have plentiful recordings of small earthquakes, a semi-automated approach to ground motion processing is desired. A subset of ground motions are selected for manual examination and used as a benchmark for validation of automated pulse-picking methods. Since the P-wave method uses the velocity (rather than acceleration) traces, baseline drift (nonzero local average velocity owing to cumulative integration of high- and/or low-frequency noise) is an issue. Automated methods for pulse-picking are effectively blind to baseline drift and may yield meaningless results. Some previous studies have been applied in relatively low-seismicity regions and hence the drift problem has been amenable to manual processing or culling. In this study, some effort is dedicated to assessing the degree to which an automated "local baseline correction" approach reduces the quality of V_{S30} estimates by comparison with manual processing and culling, and how this changes bias and variance.

Another avenue of investigation is the impact of one- versus two-dimensional representations of the regional velocity profiles used to generate V_{S30} estimates. The results indicate that if it is available, using a more detailed two-dimensional "slice" representation yields a significant benefit in terms of precision and accuracy of V_{S30} estimates. This is a unique contribution to the approach, although it can only be applied in regions where sufficiently detailed regional-scale P-wave velocity models are available.

Finally, some tentative investigations into the limitations of the P-wave method are presented. These focus on the degree to which the real world departs from the idealised representations assumed by the P-wave method, and how such departure can be quantified using information at hand, such as surface topography and the phase characteristics of the first radial and vertical wave arrivals.

Acknowledgement

In recent years a simple pleasure has been pondering how to thank all the important people on a single page. The task has only become more enormous as more excellent people have entered my life. It is now obvious that there is not enough space to thank everyone by name, and of course the more people you add to the list, the more inexcusable it becomes to forget someone. Long lists of names are also boring. Most of my friends and colleagues past and present must take me at my word that I think the world of them. There are a few obvious exceptions. I thank my greatest teachers—my parents and brother and sister, Diana and David and Isaac and Amelia, and my grandparents, aunts and uncles, and cousins, who have forgiven me for wandering far from home. My colleagues, including fellow students, postdocs, and office mates, have been great teachers and supporters in recent years, which is all the more remarkable since it is mostly thankless. Cogs in the "money machine that eats quality and shits quantity" still turn with integrity and generosity, taking great care on many small and selfless acts. I owe a great debt of gratitude to my advisors, Benedikt Halldórsson, Russell Green, Adrian Rodriguez-Marek, Chris McGann, Liam Wotherspoon, and Brendon Bradley for giving me incredible opportunities and for being patient and kind. Lessons learned from past mentors like Bruce McCormick, Dave Deardorff, Wally Damon, Brent Tkaczyk, Tim Cox, and Rita Dana have never been forgotten. As for everyone else, if you are bothering to read this, then it is a virtual certainty that I am routinely grateful for our paths having crossed. In lieu of pages more names I have devised the following grouping scheme which covers almost everyone: my dear friends from Northwood and nearby cowtowns, the Nottingham Congregational Church, soccer teammates and cross-country cultmates, all my teachers not mentioned above, music-makers, the Camp Yavneh clan, my RSE and RPI family, my Blacksburg friends including the extended VT, Abby's and Klausberg coagulations, many excellent housemates, the Riversiders and Gulli's gang, my Colorado comrades especially Junglefam and the Bernie Brigade, my University of Canterbury peers, the New Zealand ravers and the RAD Bikes volunteers. To all who took a chance on me or gave of their precious time to teach, listen, advise, or just share experiences of the typical self-aware meatbag variety, it is impossible to pay you back, but I hope someday I will have paid it forward.

> Kilgore Trout once wrote a short story which was a dialogue between two pieces of yeast. They were discussing the possible purposes of life as they ate sugar and suffocated in their own excrement. Because of their limited intelligence, they never came close to guessing that they were making champagne.
>
> — *Kurt Vonnegut*

To my grandparents

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Chapter 1

Introduction

1.1 Geotechnical Site Response and V_{S30}

In geotechnical earthquake engineering, “site response” refers to the problem of assessing the salient characteristics of a site of interest for civil engineering design, construction and/or hazard analysis. The site is generally considered on the scale of at least tens and generally hundreds of metres in the vicinity of an existing or hypothetical engineering structure that has experienced or will experience dynamic loading in an earthquake. The most important mechanical characteristic in the context of earthquake loading is stiffness, as measured by elastic moduli. Since stiffness can vary dramatically in different earth materials (*i.e.,* soil is generally softer/less stiff than rock), and since this has a dramatic effect on the frequency content and amplitude of ground motion during an earthquake, the site response problem is the primary challenge in geotechnical earthquake engineering research and practice.

V_{S30} is the time-averaged shear wave velocity (V_S) in the uppermost 30 metres of the earth’s surface, assuming vertically-propagating waves. “Time-averaging” means computing V_{S30} as the ratio of distance to travel time, *i.e.* $\frac{30\text{m}}{t_{30\text{m}}}$. For a site comprising n horizontal, laterally-extensive geologic layers from depth zero to thirty metres, each layer having a height H_i and vertical shear wave velocity V_{S_i},

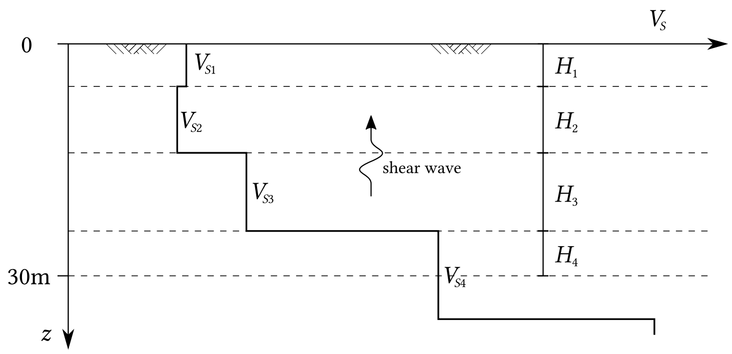

Figure 1.1: V_{S30} is the time-averaged wave velocity (V_S) for the uppermost 30 metres, assuming vertically-propagating shear waves. It can be computed as the ratio of thirty metres over the thirty-metre travel time.

V_S can be represented as a piecewise-constant function of depth and the travel time for each layer is $t_i = \frac{H_i}{V_{S_i}}$, so

$$V_{S30} = \frac{30\text{m}}{\sum_{i=1}^{n} \frac{H_i}{V_{S_i}}} \tag{1.1}$$

(Figure 1.1).

V_{S30} is one of the most commonly used engineering parameters for assessing the geotechnical softness or stiffness of a site for geotechnical earthquake engineering design and hazard analysis. V_{S30} cannot capture all salient information about the site response problem. Other important considerations include the depth of a soil deposit (all else being equal, a deeper site has a longer fundamental period of vibration); the presence or absence of shear wave velocity reversals (geological deposits where there is a departure from the typical tendency for V_S to increase monotonically with depth); basin effects (where the presence of lateral geological discontinuities, such as in alluvial basins, precludes or limits the ability to use simplified one-dimensional assumptions about site geology); and topographic effects (wherein the observed ground motions on hills and ridges are influenced by their geometry) (Castellaro et al., 2008; Dobry et al., 2000; Steidl, 2000; Park and Hashash, 2004; Lee and Trifunac, 2010).

Despite known limitations, V_{S30} is nevertheless a central component of the standard of practice in geotechnical earthquake engineering. It is used for site classification in design provisions such as (*e.g.*) Eurocode 8 (CEN, 1994), NZS1170.5 (King et al., 2004), and the NEHRP (National Earthquake Hazards Reduction Program) guidelines (FEMA, 2003). These codes employ broadly similar classification schemes whereby sites are categorised primarily on the basis of V_{S30}. Although periodically revised and varying from place to place, these site classes have generally been labeled alphabetically from A (hard rock) to E or F (soft soil). Hard rock sites tend to transmit high frequency seismic waves well, while softer sites often exhibit damping (energy dissipation) of higher-frequency seismic waves while amplifying lower frequencies. All engineered structures can be characterised as having a certain fundamental vibrational frequency, and a key aim of earthquake engineering is avoiding resonance conditions. Seismic site classes thus provide the parameters used by building codes to construct target seismic design spectra representing the minimum seismic standards for which buildings must be designed.

Some specific conditions such as liquefiable or organic soils occasionally govern design and result in an E or F designation irrespective of V_{S30}—the intent being to account for some of the aforementioned physical factors besides stiffness that can impact site response. These situations frequently warrant a site-specific study that takes into account a more sophisticated characterisation of local conditions than site class alone. Still, in part because these other factors are challenging to distill into simple "one-size-fits-all" criteria suitable for widespread adoption in codified form, V_{S30} remains the primary determinant of site class designation and is one of a few "must-have" parameters that is required at the earliest stages of a proposed design.

1.2 Motivation

To summarise the preceding section, V_{S30} is a useful, albeit imperfect and incomplete, metric for quantifying aspects of the site response problem. Its widespread use and near-universal acceptance mean that it will remain a convention in geotechnical earthquake engineering practice for the foreseeable future. This thesis takes as a given that V_{S30} is both useful for, and limited in, engineering application. The goals of the work presented herein are (a) improve engineering practioners' ability to estimate V_{S30} when measurements are not available and (b) contribute to the state of knowledge about the estimation methods considered. (Broader considerations, such as the well-understood limitations of the V_{S30} parameter, are beyond the scope of this work.) This section gives a brief summary of approaches to obtaining V_{S30} in engineering practice in order to contextualise and demonstrate the relevance of the remainder of the thesis.

1.2.1 Obtaining V_{S30} Values

V_{S30} can be measured directly (by deploying field personnel and equipment to advance a geotechnical sounding to thirty metres' depth), indirectly (by deploying personnel and equipment to estimate V_{S30} by observing waves at the ground surface, without the expense of vertical soundings), or estimated via alternative methods such as examining correlations between V_{S30} and other information. These three alternatives are introduced below in decreasing order of cost in order to facilitate comparison, and thereby highlight both the utility and the limitations of non-field-based measurements. This thesis is a compilation of non-field-based approaches to estimating V_{S30}. It will be shown that the issues impacting the third alternative represent both a pressing need for engineering practitioners and an opportunity for advancing the state of knowledge.

1.2.1.1 Direct Measurements

V_{S30} can be measured directly by inducing a vertically-propagating shear wave and measuring the time to propagate to a location thirty metres vertically from the wave source. Various approaches are available but direct measurement necessarily entails the use of a source-receiver pair with a vertical separation distance of thirty metres and one of the two components located on the ground surface, with the other directly below. The source is any mechanical means of creating a shear wave. A typical source is a sledgehammer striking a block resting on the ground. The receiver is an electromechanical device, such as a seismograph or geophone, that can measure motion.

Wave speed is obtained as the ratio $\frac{\text{distance}}{\text{time}}$. Synchronisation between the source and receiver is required for accurate measurement of travel time. This is accomplished by using a "trigger" sensor to establish the moment of source excitation (*e.g.*, the moment a sledgehammer strikes a steel weight on the ground), and connecting both source and receiver to the same multichannel seismic data acquisition system. Travel time is obtained as the time lag between the "trigger" source pulse and the first arriving pulse at the receiver.

Common techniques for measuring V_{S30} directly are summarised in more detail in (*e.g.*) Woods (1978) and Robertson et al. (1986).

Owing to the costs associated with mobilising personnel and equipment for drilling, V_{S30} is expensive to measure directly. Indeed, the 30-metre depth was chosen somewhat arbitrarily because direct measurements are rarely available for greater depths (Boore et al., 1997). In other words, the cost of drilling a 30-metre borehole is on the higher end of the spectrum of costs associated with borehole drilling using widely-available geotechnical drilling equipment.

There are routinely situations where a V_{S30} value is desired and an estimated V_{S30} value is acceptable in lieu of a direct measurement for the task at hand (*e.g.* for preliminary site classification or regional hazard analyses). To address this need, a variety of approaches are available as alternatives to direct field measurement of V_{S30}.

1.2.1.2 Non-invasive measurements

Non-invasive methods employing geophysical techniques are widely used, having been developed for the mining and petroleum sectors and adapted for use in civil construction and earthquake engineering. The most common modern technique for earthquake engineering applications is the multichannel analysis of surface waves (MASW) method (Park et al., 1999). Other common approaches are passive arrays (Louie, 2001; Park and Miller, 2008; Okada, 2003) and the SASW method (Nazarian and Stokoe II, 1984).

Noninvasive measurements are less expensive than borehole drilling, but still require deployment of equipment and personnel to the site of interest and are hence useful only in the context of specific projects where budgets allow.

1.2.1.3 Alternatives to Field Methods

Much greater generality is achieved by “desktop studies;” one typical approach is to identify widely-available proxy variables with sufficiently strong correlations with V_{S30} to be useful. The most popular among these are surface geology and slope (*e.g.* Wills et al., 2000; Perrin et al., 2015; Thompson and Wald, 2012; Thompson et al., 2014; Wills and Clahan, 2006; Yong et al., 2012). The outcomes of these studies generally included maps of entire regions with continuously-available V_{S30} estimates derived from correlations. Finally, passive observations from earthquake recordings at broadband seismometers have been used by seismologists for studies of large-scale geologic discontinuities (*e.g.*, the Moho) via receiver functions (Ammon, 1997); these techniques have been more recently adapted and investigated for the geotechnical site response problem (Li et al., 2014; Ni et al., 2014).

1.2.2 Geologic, geographic, and statistical details pertinent to non-field-based methods

Both the geology and geography of New Zealand are unique in the world in several respects. Both of these have implications for the availability, quality and utility of V_{S30} data in geotechnical earthquake engineering applications. As an island nation, New Zealand's separation from other larger land masses has rendered precise dating of many geologic deposits in New Zealand challenging or impossible (GNS Science, 2016). As it pertains to V_{S30} estimation via geologic correlations (Chapter 2), this calls into question the validity of the assumption that V_{S30} is broadly consistent across similar geologies. When V_{S30} data are not available for a broad range of geologies locally, then some assumptions about applicability of correlations developed in other regions must be made, and the implications of these assumptions considered. The Bayesian approach is useful in this regard, and in Chapter 2 a significant effort is made to explicate the utility of Bayesian analysis and the assumptions embedded in the choice of priors and updating parameters. As stated in the chapter, one of the benefits of a Bayesian framework is that it allows models to be regenerated easily to incorporate new data or statistical assumptions.

Another aspect in which New Zealand geology and geography pose interesting and unique challenges for V_{S30} is the relatively sparse population density of the country. Nearly eighty percent of the country is completely unpopulated (as assessed on 1 km^2 grid squares: Douglas-Clifford, 2017). The majority of the population of New Zealand is clustered in the largest cities of Auckland, Christchurch, and Wellington. Since site-specific studies and field measurements of V_{S30} are generally only cost-effective for heavy civil construction projects, the result is that high-quality V_{S30} data are heavily clustered in a relatively small number of heavily-populated regions. Additionally, for historical reasons, cities in New Zealand (as elsewhere) have historically often been founded on alluvial geologic deposits because of the need for fertile farmland and grazing pastures, coastal access and fresh water supply, *etc.* The upshot is that available V_{S30} are clustered geologically as well as geographically—again justifying the use of the rigorous and flexible Bayesian statistical framework for assessing the statistical properties of V_{S30} data. Similarly, the relative abundance of strong motion stations on relatively flat, laterally extensive alluvial deposits (*e.g.*, Christchurch city) opens the possibility of applying geophysical methods (such as the P-wave method, Chapter 3), which rely upon simplified assumptions about the geometry of near-surface deposits.

The P-wave method will be discussed further presently but here it is also worth emphasising that it can be applied only at strong motion stations (SMS), and in New Zealand not every SMS has an associated V_S profile or V_{S30} value. To date the most complete compilation of V_{S30} estimates and/or measurements at SMS in New Zealand has been compiled by Kaiser et al. (2017). 497 stations were reported with both V_{S30} values and a quality ranking from Q1 (best) to Q3 (worst). Q3 stations comprised 424 of the stations or approximately 85% of the total. V_{S30} from Q3 stations are reported as either being from "broad-scale national V_{S30} maps [*i.e.*, Perrin et al. (2015)] and/or estimates at site with poor constraints." The Perrin et al. (2015) map, on which many of the strong motion station V_{S30} estimates are based, is in turn based upon geologists' estimates with relatively few physical measurements to constrain them. In recent years, following the 2010-2011 Canterbury Earthquake Sequence, research efforts have sought to improve the number and quality of available V_{S30} field measurements in cities and/or at strong motion stations (*e.g.,* Wood et al., 2017; Deschenes et al., 2018; McGann et al., 2017), but many SMS subsurface profiles still need to be characterised.

1.2.3 Summary

The aforementioned issues—namely the cost and paucity of field measurements/estimates of V_{S30}, and the various technical considerations applicable to the alternatives, including no small degree of judgment—comprise the primary impetus for the research undertaken and reported in this thesis. The work presented herein has been a continuation and extension of some of the efforts introduced above for estimating V_{S30} in the absence of field measurements—namely the development of maps for V_{S30} using proxy variables (Chapter 2) and the evaluation of the methods proposed by Ni et al. (2014) for estimating V_{S30} using recordings of many small earthquakes at seismic strong motion stations (Chapter 3). These two approaches are distinct insofar as they employ unique methods relying on mostly non-overlapping bodies of theory and observational data (the former employing statistics to explicitly codify inferences about the correlations between V_{S30} and various features of surface geology and topography and generate a V_{S30} map that is continuous across New Zealand; the latter employing simple wave physics, weak earthquake recordings, and a coarse three-dimensional regional velocity model to obtain estimates of V_{S30} at discrete locations corresponding to strong motion recording stations). They are closely related and comprise a cohesive work insofar as their results both solve the same problem, namely the need to estimate V_{S30} and associated uncertainty in contexts for which field testing is too costly to be performed.

1.3 Organisation

The introductory material above is intentionally brief, and intended to highlight the motivation for this research in broad strokes rather than by way of a comprehensive literature review. This is mainly for brevity, because each of these major research efforts draws on an essentially unique body of background literature, and is prepared in a style ready for publication. Chapter 2 has already been published in the journal *Earthquake Spectra* (Foster et al., 2019); Chapter 3 is in preparation to be submitted later in 2021. Literature review for each of the two investigations is contained at the beginning of its respective chapter. The remainder of this introduction briefly summarises the contents of Chapters 2, 3, and 4.

After some comments on the project motivation and previous work, Chapter 2 presents a multi-stage workflow for developing a statistically robust nationwide V_{S30} model. The model is first developed by subdividing a surface geology map of New Zealand into several distinct geologic categories and assigning each a best-estimate V_{S30} and corresponding lognormal uncertainty obtained from similar V_{S30} mapping projects in other regions. A similar approach is followed for a "terrain-based" model, where "terrain" categories are calculated based on the statistical properties of the digital elevation model (DEM) for New Zealand developed for geomorphological classification and previously adopted by others for a coarse global V_{S30} model. Bayesian statistics is applied to each of the geology- and terrain-based V_{S30} models so as to make use of the available New Zealand V_{S30} measurements and estimates in a statistically transparent and consistent manner. Finally, variogram models are assumed based on the spatial autocorrelation of normalized residuals representing the mismatch between geology- and terrain-based V_{S30} models and the underlying data; these variograms allow the application of geostatistical interpolation methods that reduce this mismatch in the final model. A novel approach to handling inappropriate geostatistical extrapolation across the lateral discontinuities between geologic units (where globally-derived spatial autocorrelation trends tend to overestimate the smoothness of V_{S30} variation with horizontal distance) is also presented. For each stage of the modelling process, a nationwide continuous-coverage map representing V_{S30} estimates, and a corresponding map representing model uncertainty, are produced. Appendices A, B, and C contain supplemental information about the work in Chapter 2; these respectively provide the V_{S30} measurements in tabular form, a complete listing of the unique pairings between geology map metadata and the simplified geology categories used for developing the V_{S30} model, and a more detailed presentation of the specific statistical assumptions driving the implementation of Bayesian updating in the V_{S30} mapping work. (Appendix B is very long and a link to an electronic version of the table in CSV format is also provided).

In Chapter 3, the theory underlying the so-called "P-wave method" is summarised and some discussion about the derivation and solving of the equations for V_S and V_{S30} is provided. The considerations for selecting strong motion stations and ground motion recordings for applying the P-wave method are explained. Automated algorithms for computing signal-to-noise ratio (SNR) and performing filtering and baseline correction are described. The approach for distilling available information from the New Zealand velocity model (NZVM) (Thomson et al., 2020) into a simplified one-dimensional profile and the method of estimating the ray parameter is described. A similar approach for generating more realistic two-dimensional profiles is presented. The details of the processes for manual and automated assessment of the H/V or $\frac{\dot{U}_R}{\dot{U}_Z}$ ratio, a necessary input to the P-wave method that is obtained from ground motion recordings, are given. These include manual and automated local baseline correction (LBC) strategies. The distributions of V_{S30} estimates derived from both the automated and manual LBC variants are presented, alongside field measurements of V_{S30}. The results from the two-dimensional variation are introduced and are shown to yield superior estimates to the 1-D approach. Some discussion focuses on the quality of V_{S30} estimates in terms of both precision and accuracy, as a function of SNR. (This is especially relevant for scenarios where there is no manual examination/culling of ground motion records and/or manual LBC). A nontrivial bias for low (near-vertical) takeoff angle is presented and found to be consistent with others' work. Finally, some tentative investigations into non-ideal strong motion station sites and/or recordings are presented, with the goal of elucidating some physical interpretations of unusual results. A brief discussion on solution of the fundamental equation for V_S (which contains a quadratic and yields two roots) is provided in Appendix D. Appendix E gives information about an electronic file containing all event-station pairs used in the P-wave method study, along with data such as computed SNR, assumed refraction location and associated geometry for the one-dimensional case, P-wave velocities, ray parameters, V_{SZ}, and V_{S30}. This information can be used by others attempting to replicate aspects of this study or its methods.

In the concluding remarks (Chapter 4), some general comments are given on the outcomes presented in Chapters 2 and 3 and some suggestions for future work provided.

1.3.1 Remark on intellectual integrity

A comment on intellectual integrity follows, since I (Kevin Foster) am not listed as the sole author of the work in Chapter 2 as published in *Earthquake Spectra*, nor will I be the sole author of the manuscript in Chapter 3 when it is submitted for publication in a scholarly journal. As is conventional, I have credited academic colleagues—supervisors and co-supervisors—as coauthors since they have suggested the research topics and generously offered technical and editorial guidance in their roles as mentors. Nevertheless, I am responsible for carrying out all of the work presented herein, including the majority of the intellectual input not attributed to other researchers in the citations given, with exceptions as follows: Brendon Bradley advocated the use of the geostatistical interpolation method which we have labeled the "MVN" (multivariate normal) approach in Section 2.5 (instead of conventional regression kriging), as well as the decision to develop separate variograms for the geology- and terrain-based residuals (Section 2.5.2). Brendon also suggested the asymptotic functional form for the covariance reduction factor (Equation 2.6). While the use of the first person is limited in the manuscripts, plural pronouns such as "we" or "our" (rather than the singular "I," "mine," *etc.*) do appear in a few instances. The first person, when it is used, is intended to emphasize that a subjective decision was made to select one course of action among multiple alternatives, and/or to highlight a choice's uniqueness by comparison with previous work by others. The plural forms of the pronouns are consistent with multiple coauthors in the already- or soon-to-be-published manuscripts. Notwithstanding the occasional appearance of a plural first person pronoun, the work presented is my own.

Chapter 2

A V_{S30} Map for New Zealand Based on Geologic and Terrain Proxy Variables and Field Measurements

Abstract

A time-averaged 30-meter depth shear wave velocity (V_{s30}) map is developed for New Zealand as a weighted combination of a geology-based and a terrain-based model. A Bayesian updating process allows local V_{s30} measurements to control model estimates where data exist, and uses model estimates developed for other parts of the world where local data are sparse or nonexistent. Geostatistical interpolation is performed on the geology- and terrain-based models using local V_{s30} measurements to constrain the model in the vicinity of data. Conventional regression kriging is compared with a flexible multivariate normal (MVN) approach that allows for arbitrary assumptions regarding measurement uncertainty at each data location. A modification to the covariance structure in the MVN application allows for more realistic estimates by reducing undesirable extrapolation across geologic boundaries. The results of kriging and MVN approaches are compared.

The geology- and terrain-based MVN models are combined to produce a final model suitable for engineering applications. 100m resolution map outputs are publicly available.

This chapter is published as:

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2.1 Introduction

V_{S30}, the time-averaged vertical shear wave velocity in uppermost 30 meters, is widely used in earthquake engineering research and practice. Owing to the expense and difficulty of measuring V_{S30} directly, recent work has been devoted to developing V_{S30} models using V_{S30}-correlated proxy data. The work presented herein represents an attempt to incorporate the best recent practices for modeling V_{S30} (*e.g.*, Yong et al. (2012); Thompson et al. (2014); Parker et al. (2017); Ahdi et al. (2017b)) using both available proxy data and direct V_{S30} measurements (with arbitrarily specified measurement uncertainty), within a statistical framework that treats uncertainty as an essential model component and allows consistent incremental improvements as new V_{S30} data are collected.

Others have applied methods similar to those presented here for mapping V_{S30} by proxy methods, where continuous and readily available proxy data are correlated with V_{S30} measurements and used for estimating V_{S30} in regions where direct measurements have not been taken. Generally the proxy data include geology and topographic data. First studies from around the world are summarized and then prior work in New Zealand (NZ) is highlighted, with a focus on the additional contributions to be presented in the work herein.

Wills and Clahan (2006) developed a V_{S30} map for California based on surface geology. Geology-based V_{S30} mapping is confounded by the fact that mapped geologic units are frequently less than 30 meters thick. Wills and Clahan (2006) handled this problem for alluvial basins by assigning locations in California to "shallow" or "deep" basin categories on the basis of areal extent: narrow valleys and locations near to the base of steep mountains were assigned "shallow" categories whereas extensive basins were assigned "deep" status. Wills and Clahan (2006) also separated alluvial units into fine, coarse and mixed/undifferentiated bins for better V_{S30} discrimination. Wills and Gutierrez (2009) introduced a slope-dependent component to V_{S30} modeling. Topographic slope is slightly correlated with V_{S30}, at least for soil deposits, owing to depositional characteristics. For example, the size of particles dropping out of suspension in an alluvial depositional environment is correlated with flow velocity and, in turn, the slope of the landscape. The range and complexity of surficial rock depositional mechanisms renders this correlation virtually nonexistent for rock.

Building on the Wills and Clahan (2006) study, Thompson et al. (2014) developed a regional V_{S30} map for California that added topographic slope based modifications (Wills and Gutierrez, 2009; Allen and Wald, 2007) to soil categories. Additionally, the well-known regression kriging approach was applied to the mapping, bringing model predictions into agreement with measurements locally. The kriging uncertainty in this study can be evaluated alongside the model predictions for a first-order, low-end assessment of expected disparity between model and reality. Importantly, kriging uncertainty is entirely a product of measurement locations and "globally" derived variogram, meaning that the mapped uncertainty is not conditioned on individual geology-based polygons.

Lee and Tsai (2008) generated a V_{S30} map of Taiwan in a two-step process, first generating a correlation-based model for V_{S30} using SPT (standard penetration testing) blow counts, then applying this model to a larger dataset. The resulting model was kriged. Wald et al. (2011) proposed a generalized framework for V_{S30} mapping, recommending a hierarchal model with topographic slope (being globally available) as the primary proxy variable, and generating individual linear slope-V_{S30} relations for significant geology groups. They demonstrated the method by producing a map of Taiwan and employing kriging to honor local observations.

Vilanova et al. (2018) developed a V_{S30} map for Portugal based on geology. Statistical testing was performed on candidate geologic units to optimize discrimination. Spatial declustering methods were evaluated but found to have non-negligible impact in only one of six candidate geologic units. After eliminating non-discrimating groups only three distinct geologic categories were used in the final model.

Ahdi et al. developed geology- and topography-based V_{S30} models for Alaska (Ahdi et al., 2017b) and the Pacific Northwest (Ahdi et al., 2017a). The methods employed were similar to Thompson et al. (2014), although did not incorporate any geostatistical methods. Ahdi reevaluated the geologic classification process, and hence the final product employs geologic categories that are distinct and generally more discriminating than the Thompson et al. (2014) categories. Parker et al. (2017) developed V_{S30} estimates for Central and Eastern North America (CENA) based on geology, topographic slope, and indicator variables to indicate significant sedimentary basins and the extent of Wisconsin glaciation. Basins and past glaciation were noted as having a strong correlation with observed V_{S30} values.

Yong et al. (2012) employed an automated, DEM (digital elevation model)-based 16-category terrain classification scheme (Iwahashi and Pike, 2007) to the problem of V_{S30} modeling. The terrain classification technique divides a map domain into bins based on slope, then subdivides each bin into further categories on the basis of local convexity and a local roughness measure. The results were used to generate worldwide V_{S30} maps. A later comprehensive review of proxy-based V_{S30} measurements (Yong, 2016) examined the performance of this technique using newly available V_{S30} data in California. Another V_{S30} model for Taiwan (Kwok et al., 2018) also used terrain-based classifications, as well as the more common geology classifications, and combined the two models in a weighted fashion.

In NZ, Cousins et al. (1996) compiled geotechnical site class estimates for all strong-motion stations. The site class estimates were based on NZ Standards Association (1992). The geotechnical data used to develop these estimates, however, was sparse and/or tentative at best (*e.g.* based on geologists' estimates without any invasive explorations). Most station information, moreover, was assumed based on regional geology maps.

Destegul et al. (2009) developed a site amplification map for NZ based on geology maps. The map was then validated by comparing map polygons against 687 accelerograph locations where site class was available.[1] This map was developed before completion of the QMAP project (most recent all-NZ geologic map, GNS Science, 2016) and therefore based on geologic data from several scales ranging from 1:25,000 to 1:1,000,000. Destegul et al. (2009) also made pragmatic assumptions about the nature of soils confined in narrow valleys: class C was assigned wherever "soil units were narrow and bounded on one or both sides by weak rock." Abrupt geologic transitions were "buffered" (*e.g.* by inserting a narrow region of class C between polygons of classes B and D).

Perrin et al. (2015) published the first V_{S30} map for NZ by assigning NZS 1170.5 (King et al., 2004) site class categories using QMAP (GNS Science, 2016) categories. The resulting map provided distinct ranges of V_{S30} corresponding to the well-known site categorization scheme. The Perrin et al. (2015) map also took steps to account for varying V_{S30} at the edge of geologic basins, applying ad-hoc assumptions about lateral extents of basin edges and the dip angle of rock beneath basins. Such decisions were fairly arbitrary by necessity; e.g., dip angle assumption was driven in part by data resolution. The work drew extensively on data for geology correlations with V_{S30} based on the detailed California data in Borcherdt (1994).

[1] The method of site class assessment for these accelerograph locations in Destegul et al. (2009) was unclear. The work is attributed to Cousins and is unpublished; it may be a continuation of the Cousins et al. (1996) report wherein most site class estimates were derived from geology maps.

2.2 Approach and work flow

The present study incorporates many of the techniques applied by others in the prior work discussed above including geology-, slope-, and terrain-based proxy variables, and geostatistics for honoring local V_{S30} data. Our work builds on these methods but additionally adheres to a Bayesian framework for unifying first-order (prior) V_{S30} and uncertainty (σ) estimates gleaned from models for other regions with field data in NZ. We also apply more advanced geostatistical methods (Worden et al., 2018) than the typical regression kriging approach. Compared with previous V_{S30} models for NZ which have only used geology proxy variables, the present study adds slope and terrain proxy variables, Bayesian statistics and geostatistics.

The work flow is summarized in Figure 2.1 with a box for each incremental model developed. Every model assumes lognormal V_{S30}[2] and is therefore completely specified by two maps, a median V_{S30} map and a lognormal standard deviation (σ) map.

A geology-based model is generated by generating a simplified geologic map with categories consistent with Ahdi et al. (2017b) and applying their V_{S30} estimates from Alaska. A terrain-based model is developed based on DEM-based "terrain categories," derived from first-order properties of the DEM (local slope, convexity and texture) (Iwahashi and Pike, 2007). Terrain categories are generated for NZ and assigned V_{S30} values using the terrain-based estimates of Yong et al. (2012). Each of these two "prior" models are updated with V_{S30} data for NZ in a standard Bayesian framework with lognormal conjugate priors and unknown standard deviation (Gelman et al., 2014, section 3.3) . The geology-based model is modified to incorporate weak correlations between topographic slope and V_{S30},

[2]The assumption of lognormal distributions when modeling V_{S30} is so widespread and generally accepted that explanations for this choice are virtually nonexistent in the literature. Expert opinion generally defers to two justifications for this choice: (1) It works (*i.e.*, sufficiently large collections of V_{S30} measurements can be described fairly well by a lognormal distribution, irrespective of other factors such as subsetting by region or geology); and (2) lognormal distributions do not allow for negative values, which ensures consistency with the laws of physics.

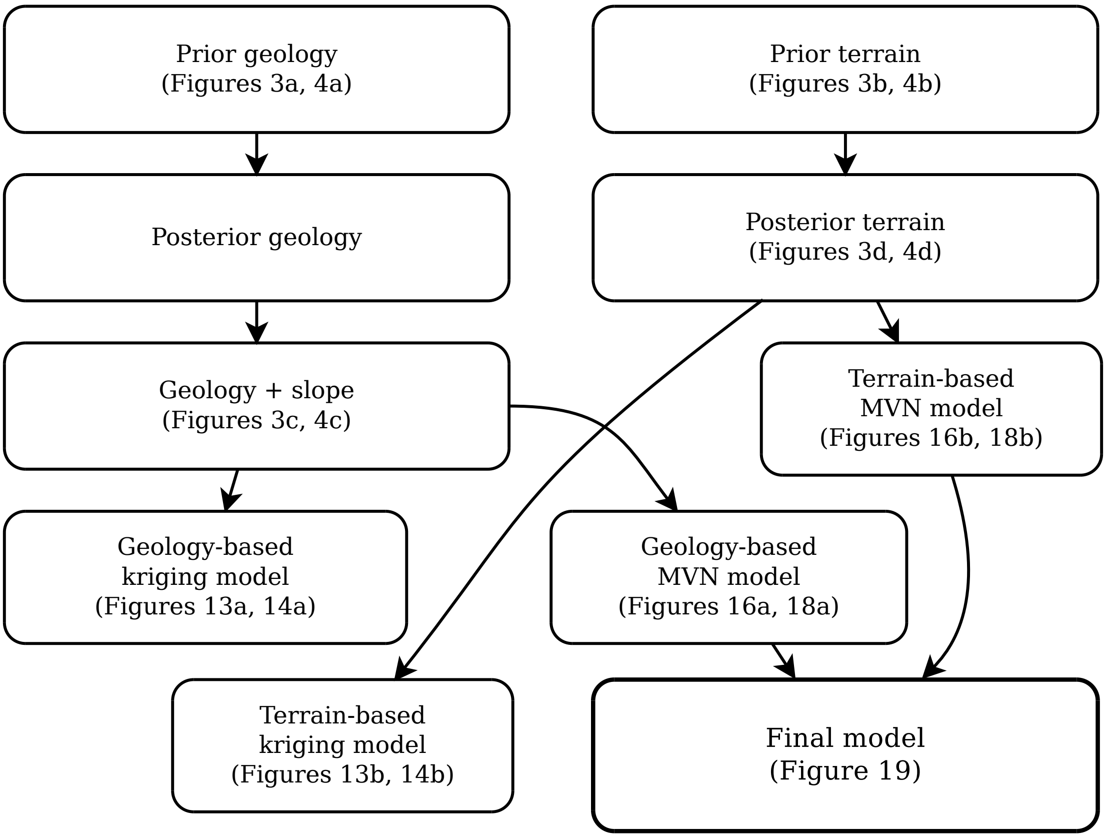

Figure 2.1: Relationships among various model components. Arrows indicate incremental model refinements.

similarly to Thompson et al. (2014); Ahdi et al. (2017b); Parker et al. (2017).

Sample variograms are generated using the residuals corresponding to each of the two constituent models, and theoretical variograms are fitted for forward prediction. Two geostatistical interpolation methods are applied to each of the constituent models: conventional regression kriging (RK) and a multivariate approach (Worden et al., 2018) ("MVN") with a novel additional contribution to automatically and intuitively reduce undesired extrapolation across geologic discontinuities. Finally, a "weighted" model is generated as a statistically weighted combination of the MVN models.

2.3 Data sources

The information sources used for model development include a NZ geologic map, topographic map, and V_{S30} data, as described below.

2.3.1 Surface geology and topographic data

The geologic map, also referred to as QMAP ("quarter-million" for the map scale), is a recent compilation of existing surface geologic maps for regions across NZ (GNS Science, 2016). The data is in vector form, with coordinates indicating each corner of approximately 55,000 polygons, each with several metadata fields. Geologic boundaries (polygon edges) are accurate to ±250 meters. The topographic data source is a digital elevation model (DEM) developed by LRIS NZ (Landcare Research New Zealand, 2010; Barringer et al., 2002) and is available at 25m resolution. We use the DEM resampled to more manageable 100m and 270m resolutions for the terrain and slope proxy variables, respectively.

2.3.2 V_{S30} data

V_{S30} data are from three datasets as shown in Figure 2.2: Kaiser et al. (2017); McGann et al. (2017) and a compilation of recent surface-wave-based field investigations in Canterbury. The word "data," as opposed to "measurements," is deliberate; most V_{S30} input data are not from direct measurements. The most striking feature of Figure 2.2 is the lack of data over most of the country; this is in part because much of New Zealand is sparsely populated which has obviated the need for V_{S30} measurements in most areas. The following paragraphs describe each dataset in turn, followed by the assumed measurement uncertainties. A complete tabular listing of input V_{S30} data is provided in Appendix A.

Kaiser et al. (2017) compiled a list of V_{S30} values and/or estimates for NZ strong motion stations. Along with V_{S30} measurements, qualitative quality rankings (ranging from Q1=best to Q3=worst) were provided for each station. Q1 data include both well-constrained surface wave-based methods and invasive methods. Q2 data may be based on well-established local correlations, similar nearby sites, and/or well-constrained near-surface V_S profiles that do not necessarily reach 30m depth. Q3 values are based solely on estimates, either from preexisting national scale maps (Perrin et al., 2015) or from geologists' estimates. We do not use Q3 data for V_{S30} modeling here. (Most seismic stations' V_{S30} estimates are in category Q3 and hence not shown in Figure 2.2). A number of possible duplicate observations were encountered in the Kaiser et al. (2017) dataset, so a preliminary screening was implemented where duplicates (identified as V_{S30} points within two meters of another observation) were removed.

McGann et al. (2017) used CPT (cone penetration testing) correlation-derived V_{S30} values (McGann et al., 2015) to produce a regional V_{S30} map for the Christchurch area. For our purposes these data were too numerous (by comparison with the data available for the rest of NZ), and without downsizing would overwhelm the impact of data elsewhere. Accordingly, the McGann et al. (2017) data were resampled from 7,402 points to 280 points by overlaying a 1km grid and selecting the nearest McGann data point to each gridpoint (Figure 2.2). This decision was arbitrary but reasonable for the goals of the model development.

The "surface waves" dataset refers to a compilation of V_{S30} data from several surface wave analysis-based site investigations performed following the 2010-2011 Canterbury earthquake sequence (Cox et al., 2011; Wood et al., 2011; Wotherspoon et al., 2013; Van Houtte et al., 2014; Wotherspoon et al., 2016; Wood et al., 2017; Teague et al., 2018). Cox et al. (2011) compiled a rapid preliminary report of surface wave testing (MASW) performed in Christchurch after the 2010-2011 earthquake sequence along with inverted site profiles from which V_{S30} estimates were obtained. Wood et al. (2011) and Wotherspoon et al. (2013) performed passive and active surface wave testing at 13 strong motion stations in and near Christchurch city to obtain V_S profiles from which V_{S30} were obtained. V_{S30} values reported in Wood et al. (2011) have been adjusted in the present work based

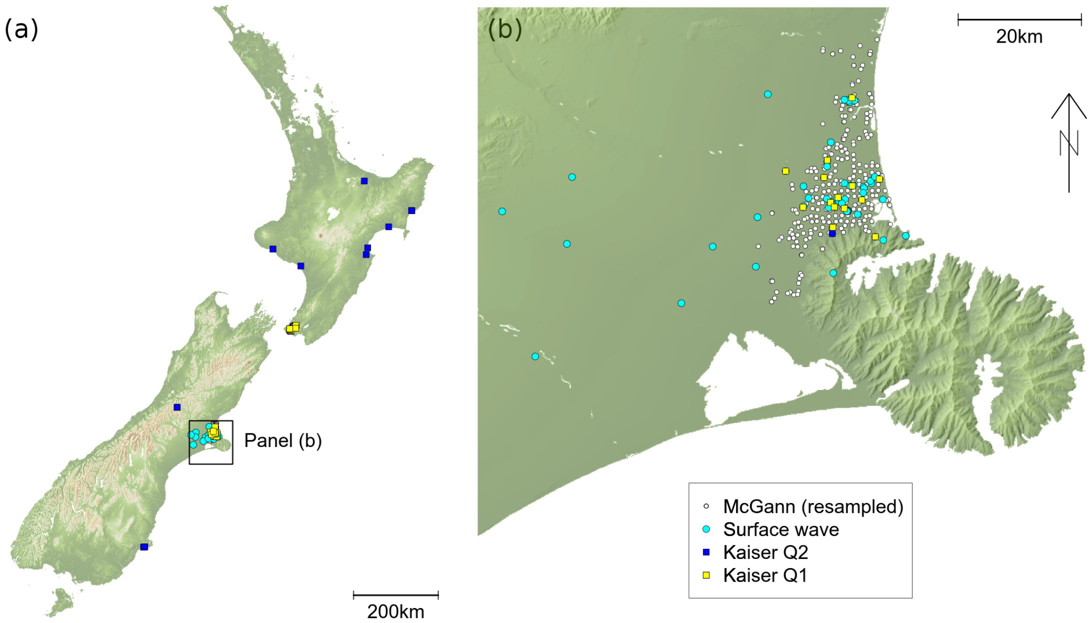

Figure 2.2: (a) Data locations for all of NZ and (b) inset showing Canterbury region for detail. McGann et al. (2017) data were downsampled based on closest proximity to an arbitrary 1km grid (white circles). Data labeled "Surface wave" (cyan circles) comprise several Canterbury-area surface wave investigations enumerated in the text. The majority of Kaiser et al. (2017) are "Q3" and are not used herein. Kaiser et al. (2017) Q2 (medium quality) and Q1 (highest quality) data are shown as blue and yellow squares, respectively.

on updated analysis of the dispersion curves. Van Houtte et al. (2014) used V_{S30} values for seven hard sites in an investigation about the role of local seismic attenuation (κ). The sites' V_{S30} were inferred from surface wave-based methods using frequencies $\geq$ 14 Hz, meaning that V_{S30} profiles could not be developed down to 30m and assumptions were used. Wotherspoon et al. (2016) report seven V_{S30} values derived from surface wave based site V_S profiles measured in conjunction with work by Cox et al. (2014). Deschenes et al. (2018) provide these seven plus two additional V_S profiles. Wood et al. (2017) evaluated liquefaction case histories at a number of sites with well-characterized V_S profiles obtained from surface wave based methods. Not all V_{S30} profiles extended to 30m depth; in a few cases where the profiles were within a few meters of 30m, Wotherspoon (pers. comm.) extended the profiles for V_{S30} estimates. Teague et al. (2018) developed V_S profiles at 14 Christchurch sites with deep and complex interbedded geology. Many candidate profiles were generated from the experimental dispersion curves to study epistemic uncertainty associated with the inversions.

2.3.3 Measurement uncertainty ($\sigma_{\text{meas.}}$)

In the subsequent V_{S30} model development we use measurement uncertainty quantified as $\sigma_{\text{meas.}}$, assuming lognormal distributions. Kaiser et al. (2017) give approximate subjective uncertainty quantities of 10% and 20% for Q1 and Q2 data respectively. Accordingly, we assigned lognormal standard deviations for measurement uncertainty ($\sigma_{\text{meas.}}$) of 0.1 and 0.2 respectively. All other data are assigned $\sigma_{\text{meas.}} = 0.2$. These uncertainties are broadly consistent with both the uncertainties provided by Kaiser et al. (2017), and with the general findings of Moss (2008) for V_{S30} determined from surface wave-based measurements and geology correlations.

2.4 Geology- and terrain-based models

The development of the geology- and terrain-based models (in the context of Figure 2.1) is summarized in Figures 2.3 and 2.4 (V_{S30} and σ, respectively). The individual maps/panes shown in these figures are recalled and discussed in detail in the subsequent subsections as they arise. These maps show only the Canterbury region for clarity; the models for all of NZ are available in the electronic supplement.

2.4.1 Geology-based prior model

To assign geology-based median V_{S30} and uncertainty estimates, all map locations first need to be assigned one of a finite number of geologic categories, "flattening" the multidimensional textual metadata underlying the geology map into a simpler, "one-dimensional" map (Figure 2.5a). The geology categories of Ahdi et al. (2017a,b) are selected so that direct comparisons can be made, for straightforward Bayesian updating, and because the geology categories chosen by Ahdi are more specific and discriminating than in many similar studies (and hence more flexible for our application). Ahdi et al. generated V_{S30} maps for the Pacific Northwest region of North America (2017a) and Alaska (2017b). The categories are enumerated in Table 2.1.

The 18 geology categories of Ahdi et al. are followed with two exceptions. Firstly, groups 2 and 3 (Fraser river) are discarded because of their regional geologic specificity. Secondly, groups 7 and 13 (fine and coarse floodplain deposits, respectively) are merged because of the difficulty in distinguishing between the two on the basis of the NZ surface geology metadata. Group 7 is not populated, and all floodplain deposits are lumped together into category 13. Merging these categories is likely more appropriate than retaining the fine/coarse distinction, even if it were practical: Wills and Gutierrez (2009) discuss the reasons that grain size at the ground surface is not generally correlated with grain size over the

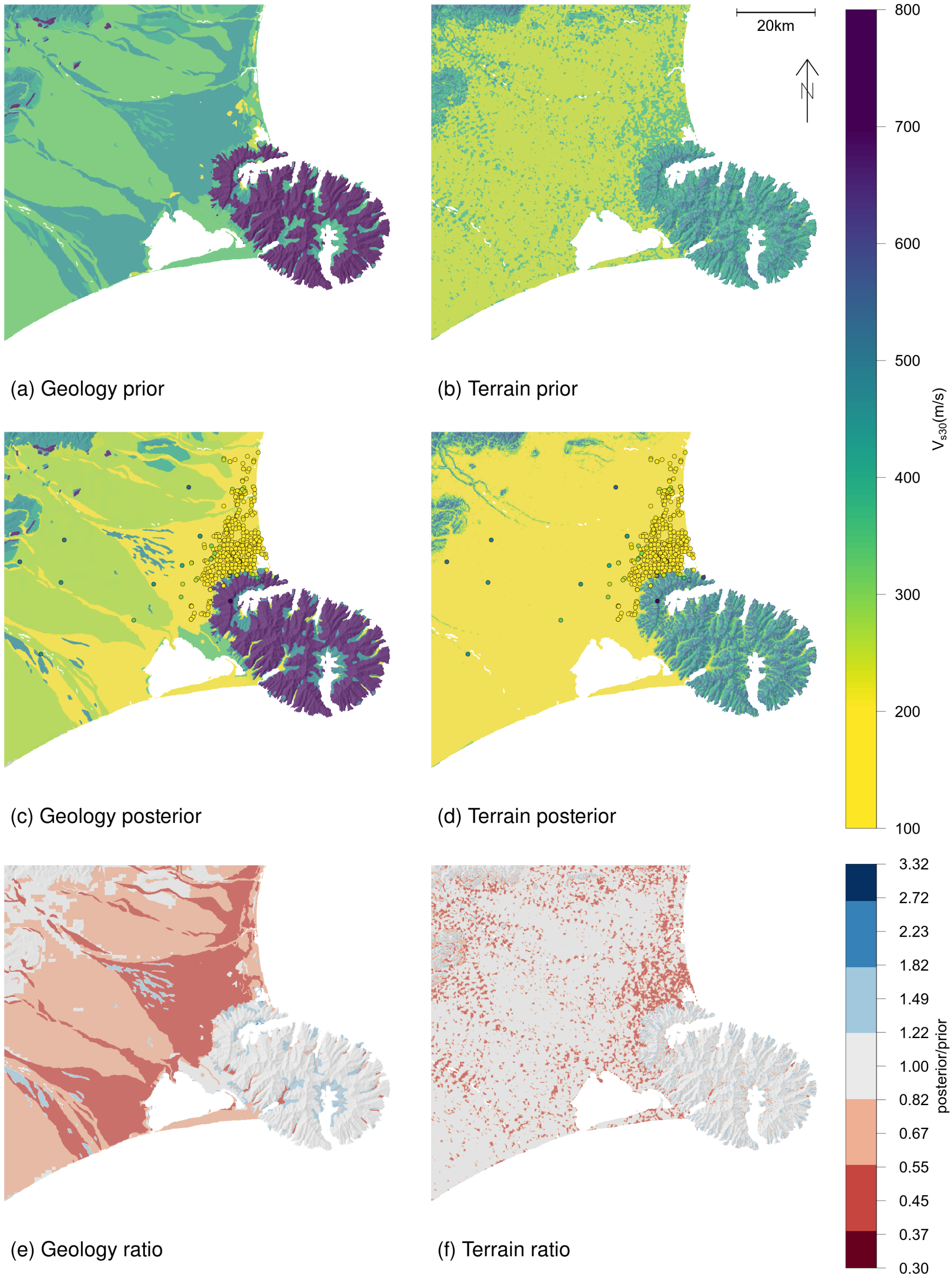

Figure 2.3: Illustrative regional (Canterbury) V_{S30} maps for various stages of model development: (a) Prior geology model; (b) prior terrain model; (c) posterior geology model with slope-based adjustment; (d) posterior terrain model. Comparison of prior to posterior models: (e) ratio of pane (c) to pane (a); (f) ratio of pane (d) to pane (b). Point overlays in panes (c) and (d) show V_{S30} measurements used for updating.

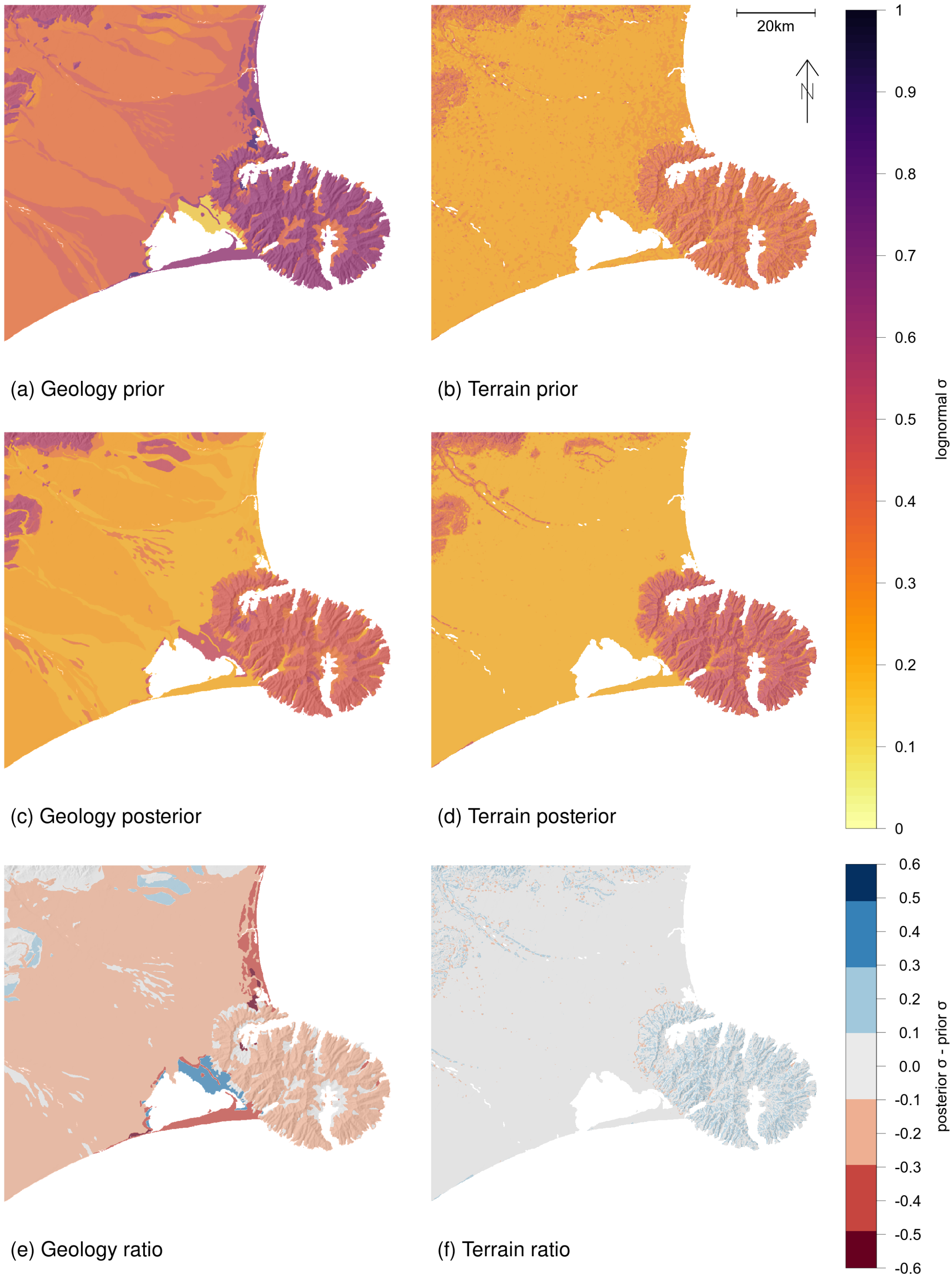

Figure 2.4: σ (sigma) maps for various stages of model development: (a) Prior geology model; (b) prior terrain model; (c) posterior geology model with slope-based adjustment; (d) posterior terrain model. Comparison of prior to posterior models: (e) difference between panes (c) and (a); (f) difference between panes (d) and (b).

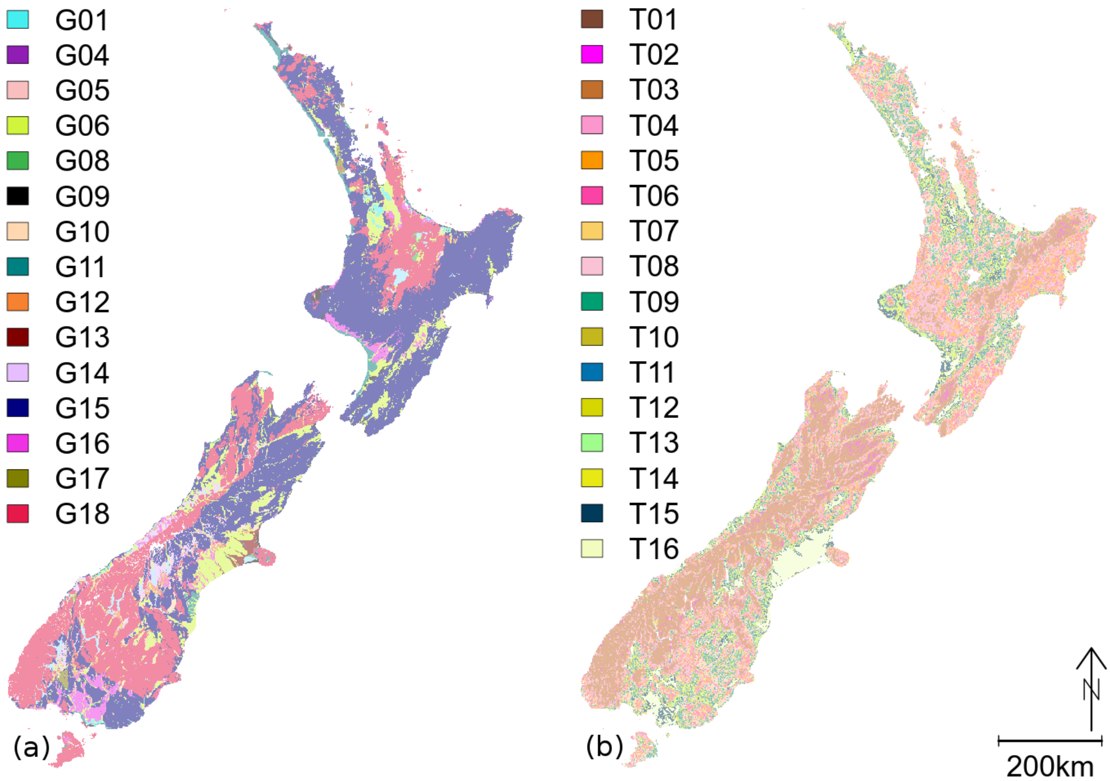

Figure 2.5: (a) Map of geology categories from Ahdi et al. (2017) as applied to NZ. (b) Map of terrain categories from Iwahashi and Pike (2007) as applied to NZ. Terrain colors are selected for direct comparison with Yong et al. (2012).

entire uppermost 30 meters for young alluvial deposits, meaning that for these depositional environments, little or no correlation is expected between fine and coarse surface deposits.

The categorization process is implemented using primarily text-based search. Extensive and iterative examination of the metadata fields is performed manually, and five metadata categories are chosen based on the richness of information they carry related to V_{S30}. A complete listing of every unique combination of the five metadata categories and the chosen Ahdi et al. (2017b) category is provided in Appendix B. The first-order geology-based V_{S30} model—using V_{S30} and σ values from Ahdi et al. (2017b)—is shown in Figure 2.3a (V_{S30}) and 2.4a (σ). The values assigned to these models correspond to the “prior” columns in Table 2.1.

2.4.2 Terrain-based prior model

Iwahashi and Pike (2007) proposed a method of using a DEM to automatically generate a map of terrain categories that roughly correlate with surface geology and/or geomorphology. The method relies on successive discrimination based upon three spatial fields, respectively: topographic slope, local convexity, and texture. The approach follows a “nested-means” logic (i.e. the categories are divided first on the basis of comparing local slope to mean slope for the entire map domain, then subdivided by convexity and texture respectively.) It can be used to generate terrain classes comprised of 8, 12, or 16 unique categories, with 12- and 16-class discrimination achieved by repeated subdivision of the regions with low topographic slope. We followed Yong et al. (2012) in choosing the 16-category implementation; this decision is justified presently in the context of the Bayesian updating step. One advantage of the Iwahashi and Pike (2007) method (in contrast to other similar classification schemes) is that it is “unsupervised,” *i.e.* no decisions need be made regarding the values (slope, convexity, texture) defining boundaries between terrain classes. One downside of the approach is that these boundary values are based on computing the mean for the map domain, yielding different maps for different domains. This restriction implies that application-specific calibrations are important.

We generated rasters for the Iwahashi and Pike (2007) categories in NZ using the DEM resampled at 100 meters (our final target map resolution).[3] By contrast, the worldwide classification by Iwahashi and Pike (2007) used the 1 km resolution Shuttle Radar Topography Mission digital elevation model (SRTM30 DEM) (Farr et al., 2007). Because of both the DEM resolution and the domain-dependent nature of the algorithm, our categories do not precisely match the Iwahashi and Pike (2007) SRTM30-derived categories for NZ. We expect this to be of trivial consequence, both because of the roughly scale-invariant (fractal) features of

[3]The resolution of the final product is not 100m in the strictest sense, but in a "neighborhood average" sense. Slope and convexity are both computed for a 9-cell moving window, and texture is computed using a 10-cell radius.

landforms, and because of subsequent reductions in epistemic uncertainty owing to the Bayesian updating process in the next step (*i.e.* the application-specific calibration).

The newly generated 100m-resolution terrain category map is shown in Figure 2.5(b). The Iwahashi and Pike (2007) categories are listed with short descriptions (borrowed directly from Yong et al., 2012) in Table 2.2. It must be emphasized that these are mnemonic labels affixed to quantities that are purely statistical in nature; the labels do not carry strong geologic meaning. V_{S30} and σ values from Yong et al. (2012) (see "prior" columns in Table 2.2) are assigned to their corresponding categories from Figure 2.5(b), analogously to the geology-based model, to produce the prior terrain-based model (Figures 2.3b and 2.4b).

Table 2.1: Geology categories with n=number of observations per category, and prior and posterior (slope-adjusted) V_{S30} and σ values for each.

			V_{S30} (m/s)		σ	
ID	Description	n	(pri.)	(post.)	(pri.)	(post.)
G01	peat	9	161	163	0.52	0.30
G04	artificial fill	11	198	273	0.31	0.28
G05	fluvial & estuarine deposits	11	239	200	0.87	0.44
G06	alluvium & valley sediments	25	323	271	0.36	0.24
G08	lacustrine (incl. glaciolacustrine)	0	326	326	0.14	0.50
G09	beach, bar, dune deposits	70	339	204	0.65	0.23
G10	fan deposits	5	360	247	0.34	0.34
G11	loess	4	376	473	0.38	0.35
G12	glacigenic sediments (drift & outwash)	0	399	399	0.30	0.50
G13	flood deposits	252	448	197	0.43	0.20
G14	glacial moraines & till	0	453	453	0.51	0.51
G15	undifferentiated sediments & sedimentary rocks	0	455	455	0.55	0.55
G16	terrace deposits & old alluvium	2	458	335	0.76	0.60
G17	volcanic rocks & deposits	0	635	635	0.99	0.99
G18	crystalline rocks (igneous & metamorphic)	4	750	691	0.64	0.45

2.4.3 Bayesian updating using NZ data

This section describes the development of posterior models as shown in the second row of Figure 2.1. Among the desirable aspects of Bayesian analysis are

Table 2.2: Terrain categories with n=number of observations per category, and prior and posterior (slope-adjusted) V_{S30} and σ values for each.

			V_{S30} (m/s)		σ	
ID	Description	n	(pri.)	(post.)	(pri.)	(post.)
T01	Well dissected alpine summits, mountains, etc.	0	519	519	0.35	0.50
T02	Large volcano, high block plateaus, etc.	0	393	393	0.42	0.50
T03	Well dissected, low mountains, etc.	0	547	547	0.47	0.50
T04	Volcanic fan, foot slope of high block plateaus, etc.	0	459	459	0.35	0.50
T05	Dissected plateaus, etc.	2	402	324	0.31	0.41
T06	Basalt lava plain, glaciated plateau, etc.	7	345	301	0.28	0.31
T07	Moderately eroded mountains, lava flow, etc.	3	388	536	0.42	0.38
T08	Desert alluvial slope, volcanic fan, etc.	3	374	515	0.32	0.38
T09	Well eroded plain of weak rocks, etc.	4	497	284	0.35	0.36
T10	Valley, till plain, etc.	6	349	317	0.28	0.33
T11	Eroded plain of weak rocks, etc.	2	328	267	0.27	0.40
T12	Desert plain, delta plain, etc.	0	297	297	0.29	0.50
T13	Incised terrace, etc.	15	500	217	0.50	0.25
T14	Eroded alluvial fan, till plain, etc.	8	209	242	0.17	0.31
T15	Dune, incised terrace, etc.	166	363	199	0.28	0.21
T16	Fluvial plain, alluvial fan, low-lying flat plains, etc.	170	246	202	0.22	0.21

its amenability to simple verbal descriptions, its agnosticism of the distinction between subjective beliefs and objective data (allowing for a crude "better-than-nothing" formulation of prior beliefs encoded as wide or noninformative prior distributions), and its tendency to demand an explicit accounting of all statistical assumptions being made. Thorough discussions of the semantics of Bayesian theory and analysis are found in D'Agostini (2003); McElreath (2015). In this work Bayesian updating is performed on both the geology- and terrain-based models presented in the previous section. Since Bayesian updating is intuitive, the updating is described here at a high level first. The next section discusses some important implementation details.

2.4.3.1 Bayesian updating summary

To facilitate comparison with the prior, the ratio of the posterior to prior models' V_{S30} estimates is presented in Figure 2.3 (e,f).[4] The greatest changes

[4] Panes c and e in Figure 2.3 refer to the posterior geology with slope modification, discussed subsequently; this is nearly the same as the posterior geology without slope modification which is

to the geology model resulting from the updating process are in the floodplain deposits (group 13) beneath Christchurch city, where V_{S30} data are abundant and generally lower than for the comparable soil units from Ahdi et al. (2017b) in Alaska. The σ maps corresponding to the posterior geology- and terrain-based models are shown in Figures 2.4c and 2.4d.

The median and standard deviation of each group's prior and posterior V_{S30} distributions are concisely summarized alongside the data in Figure 2.6 (geology) and 2.7 (terrain). Here the gray circles represent the NZ V_{S30} data and are plotted with transparency and a small horizontal "jitter" to reduce overplotting. The red markers and lines to the left of each group indicate the prior model median and +/- 1 standard deviation. The blue markers and lines to the right of each group represent the posterior model median and +/- 1 standard deviation. The prior and posterior median (V_{S30}) and standard deviation (σ) correspond to the V_{S30} and σ values in the maps in Figures 2.3 and 2.4.

The general behavior illustrated in Figures 2.6 and 2.7 can be summarized as follows: If the prior model and the data are in stark disagreement, the posterior model predicts a "compromise" between the data and prior, and a larger posterior σ reflects this underlying uncertainty. By contrast, if the NZ V_{S30} data are tightly clustered around the prior prediction, the posterior σ will tend to be lower than the prior σ to reflect the additional confidence conferred on the model by the data. This can be seen in Figure 2.4 (e and f). While much of the map area is negative (indicating a reduction in uncertainty from the prior to posterior models), not every category shows a reduced σ. These are categories where NZ data were sparse, and/or not in good agreement with the prior V_{S30} values from Ahdi et al. (2017b) and/or Yong et al. (2012).

The primary difference between panes e and f in Figures 2.3 and 2.4 is the lower absolute value in pane f of both figures. This shows that prior distributions were—at least in the Canterbury region—in better agreement with NZ data for the terrain-based (Yong et al., 2012) V_{S30} model than for the geology-based (Ahdi

omitted to save space. The difference between the two is trivial enough to disregard momentarily.

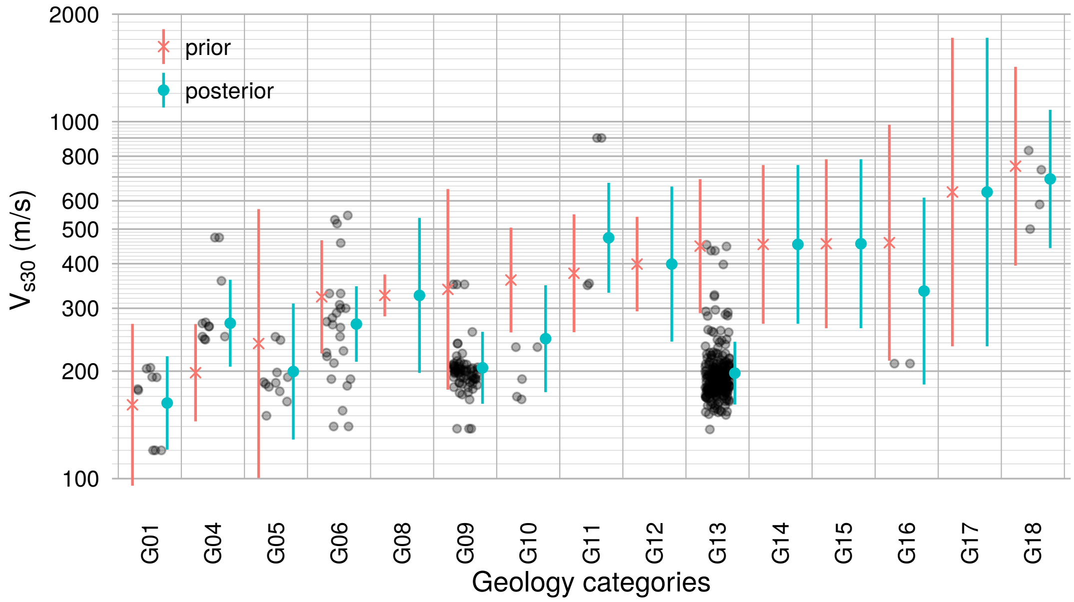

Figure 2.6: Bayesian updating for geology-based model. The colored symbols and lines represent median and +/- 1 standard deviation for lognormal prior (left, red "×") and posterior (right, blue "∘") distributions. The prior is based on Ahdi et al. (2017b). The minimum $\sigma = 0.5$ criterion is noticeable for groups G08 and G12. Gray dots represent data used for updating.

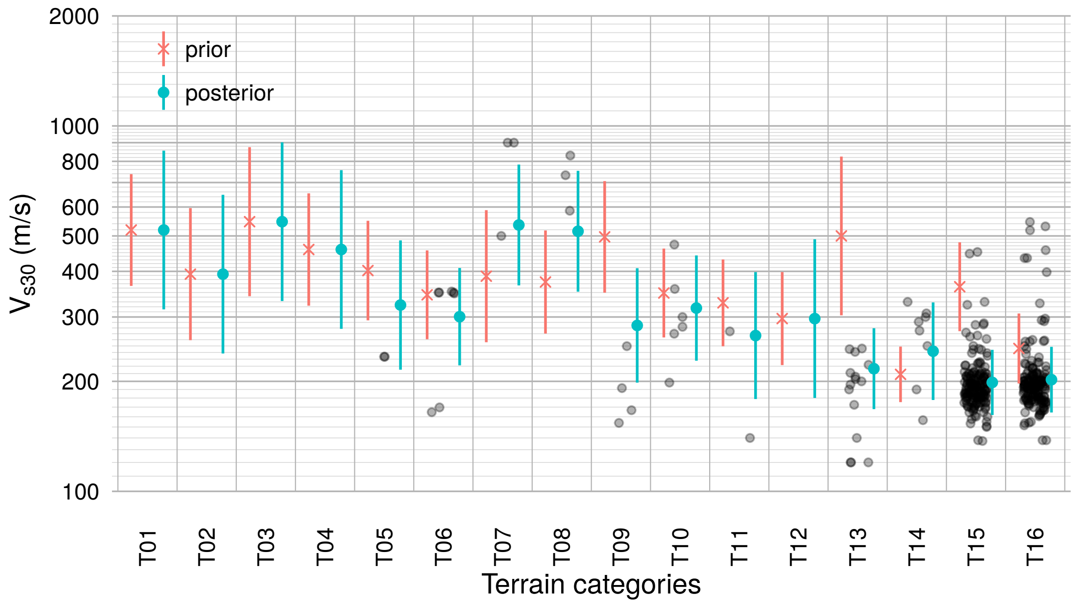

Figure 2.7: Bayesian updating for terrain-based model. The colored symbols and lines represent median and +/- 1 standard deviation for lognormal prior (left, red "×") and posterior (right, blue "∘") distributions. The prior is based on Yong et al. (2012). The minimum $\sigma = 0.5$ criterion is noticeable for groups T01, T02, T03, T04, and T12. Gray dots represent data used for updating.

et al., 2017b) model. This might suggest that the geology of California is more similar to NZ than the geology of Alaska. Alternately, or additionally, it might simply demonstrate that terrain-based V_{S30} estimation is inherently less subjective than geology-based estimation.

In the course of developing the terrain-based model, the question arises as to whether the 16-category implementation of Iwahashi and Pike (2007) is superior to the 12- or 8-category options. In particular, there is the concern of whether or not a 16-category-model is "overfitting" available data by comparison with a comparable 12- or 8-category model. We decided to use 16 categories for two reasons. First, this choice simplifies the updating process. Because Yong et al. (2012) used 16 categories, deviating from this choice would require us to "lump" the Yong categories together, introducing another form of epistemic uncertainty related to the categories' spatial distributions and sampling distributions in California and NZ. The second reason for using 16 categories is that it offers the best predictive power given the quantity of data available and its distribution across terrain categories. The motivation for using less than 16 categories would arise only if the 8- and 12-category schemes result in fewer sparsely populated categories. But on the contrary, this is not the case. The Iwahashi and Pike (2007) categories are numbered in order of decreasing topographic slope, and—due to various clustering influences already discussed—the steep categories (generally mountainous/rocky) tend to be more sparsely populated than the shallow categories (generally low-lying/soil). The result of the interaction of these various statistical biases is that the 16-category implementation gives superior discrimination in flatter regions, where V_{S30} data are plentiful, without "splitting" the data within any bins that are sparsely populated in the 8- or 12-category versions.

2.4.3.2 Bayesian implementation details

The preceding section presented the Bayesian updating process at a high level; this section contains details of the implementation that are useful for replicating our model development, including our application-specific implementation choices. This discussion adheres to the notation in Gelman et al. (2014, pp. 67-69).

The updating presumes normally distributed data (*i.e.* $\ln(V_{S30})$ is normal) with a conjugate prior distribution and unknown variance (σ^2). Two application-specific decisions are included in the discussion below. The first relates to the relative weighting between the prior and the data; the second relates to an arbitrary minimum threshold σ applied before the updating process in order to avoid overfitting caused by clustered observational data.

A transformation of variables is required to perform lognormal updating using the procedure for normal distributions from Gelman et al. (2014). Each lognormal distribution is completely specified by μ (the mean of $\ln V_{S30}$) and σ (lognormal standard deviation). σ is updated assuming a scaled inverse-chi-squared (Inv-χ^2) marginal posterior density.

As discussed, prior distributions are selected for each group using the μ and σ values reported in Ahdi et al. (2017b) for Alaska and in Yong et al. (2012) for California (Tables 2.1 and 2.2, respectively). That is to say, we view the conclusions of Ahdi et al. (2017b); Yong et al. (2012) (and V_{S30} data from Alaska and California) as sound bases for first-order estimates of V_{S30} in NZ, given no other data.

For brevity we have relegated a summary of the mathematical implementation (Gelman et al., 2014) of the approach to Appendix C. In our implementation we made application-specific assumptions about the relative weighting between the prior and data. These assumptions are reflected in the choice of initial values for the integer-valued counter variables ν_0 and κ_0 (we set $\nu_i = \kappa_i$ which is common but not required.) In Gelman et al. (2014) $\kappa_0 = \nu_0$ represent the "number of observations" contained in the prior. Quotation marks are used to emphasize that the prior is not generally a uniform dataset but may be a degree of belief or a combination of qualitative and quantitative elements. The meaning of κ_0 and ν_0 is a step removed from reality: these parameters do not reflect the process applied by Ahdi et al. (2017b) in its entirety, nor do they directly represent the number of physical V_{S30} measurements in their work. (Indeed, the clustering of V_{S30} data may mean that unique values of κ_0 and ν_0 should be chosen for each geologic group, but this is not explored further.) In any case, the choice of κ_0 and ν_0 represents a subjective decision about the appropriateness of applying Ahdi et al. (2017b) models in a NZ context. This "appropriateness" reflects issues of an epistemic nature such as (*e.g.*) the quality of V_{S30} data used in the prior study, the authors' choices of geologic grouping criteria, the degree to which NZ and California geologic deposits are essentially similar or different, and regional or discipline-specific differences in the naming and classification of deposits by various geologists.

We choose $\kappa_0 = \nu_0 = 3$ for this application. A geologic category with $n = 3$ datapoints in NZ would therefore give a posterior distribution based on equal weighting between the data and the prior distribution. Considering the available data, this choice yields a reasonable compromise between the prior distributions and the data (Figures 2.6 and 2.7).

A second application-specific decision is made regarding the σ values in the priors. Given that the observational data are sparse and clustered, there is the risk that posterior σ is artificially low because of the influence of clustered V_{S30} data when the data may not be representative of the entire map domain. To address this, we impose an arbitrary minimum value of 0.5 (natural log scale) on the model priors before applying the updating algorithm. The intent of this threshold σ constraint is to avoid overfitting in categories where V_{S30} data are few, but of similar value (*e.g.* terrain category T05 in Figure 2.7). The results of this can be seen in category groupings that are poorly constrained, such as in geology groups G08 and G12 in Figure 2.6, as well as terrain groups T01 through T05 and T12 in Figure 2.7. (Prior distributions shown are those from Tables 2.1 and 2.2; the minimum $\sigma = 0.5$ modification is only visible in the posterior distributions).

2.4.4 Topographic slope-based modification to posterior geology model

Following Thompson et al. (2014); Ahdi et al. (2017b); Parker et al. (2017), the geology-based V_{S30} model can be refined by capturing any slope-dependence in the observed V_{S30} of the various geologic groupings. To examine the slope-V_{S30} correlations, V_{S30} values were plotted against topographic slope, computed (Horn, 1981) at both 9 and 30 arcsecond resolutions for direct comparison with Thompson et al. (2014).[5] Thompson and Wald (2012) found that the correlations associated with the coarser 30-arcsecond resolution were slightly better than for 9 arcseconds, and Thompson et al. (2014) postulated that this might arise because of spurious elevation correlations from nongeomorphic features (vegetation and built infrastructure) resolved at the finer resolution in California. By contrast, in NZ the finer resolution correlations are the same or slightly better than those for the coarser resolution, and we postulate that the scale of NZ's built environment is unlikely to impact these correlations in the same way as (*e.g.*) California. Our slope-V_{S30} correlation is based on 9-arcsecond slopes.

Figure 2.8 shows the correlations of 9 arcsecond (270m) slope with V_{S30} for four geology groups. Standard least-squares fitting and likelihood testing yield linear relationships along with the ± 2 standard deviations (95% confidence) bounds shown as dotted lines. Only the geology groups with definitively positive trends are shown, and only these groups are selected for slope-dependent modification (*i.e.* the remaining geology groups are modeled with no slope dependence).

The limits of the linear fits in Figure 2.8 are shown in Table 2.3. These upper and lower slope (∇) limits were selected to define continuous piecewise-linear

[5] Actual resolutions of the 9 and 30 arcsecond maps are about 270 and 900 meters respectively; north-south arc-seconds and east-west arc-seconds are not similar in NZ.

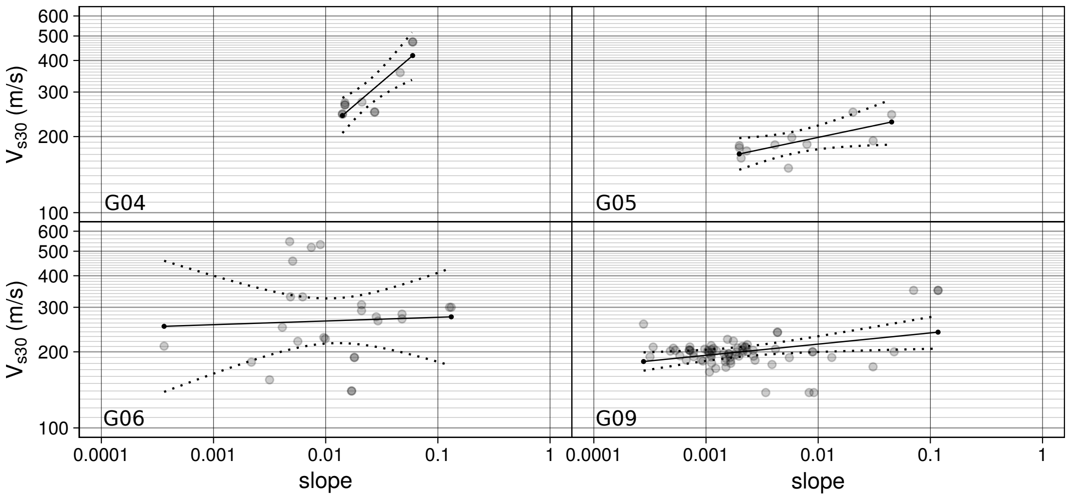

Figure 2.8: Slope dependence of geology-based V_{S30} model. Slope resolved from 9 arcsecond (~270m) digital elevation model. Only the four geology categories with positive trends are shown. Dotted lines indicate ±2 standard deviations (95% confidence bounds) on slope fit.

functions (after log transformation) defined by $(\nabla_0, V_{S30,0})$ and $(\nabla_1, V_{S30,1})$:

$$\ln V_{S30} = \begin{cases} \ln V_{S30,0} & \nabla \leq \nabla_0 \\ \ln V_{S30,0} + \dfrac{\ln(\nabla/\nabla_0)}{\ln(\nabla_1/\nabla_0)} \ln\left(\dfrac{V_{S30,1}}{V_{S30,0}}\right) & \nabla_0 < \nabla \leq \nabla_1 \\ \ln V_{S30,1} & \nabla_1 < \nabla \end{cases} \tag{2.1}$$

from which any value of slope yields a single V_{S30} value that is constrained not to extrapolate beyond the range of observed data. A more sophisticated approach might use logistic curves rather than piecewise-linear, and might expend more effort in determining whether the highest and lowest observed slopes are the "best" places to define the inflection points of the function, but we view our approach as simple, objective and effective.

Table 2.3: Slope adjustment details for categories G04, G05, G06, G09.

ID	∇_0	∇_1	$V_{S30,0}$	$V_{S30,1}$	$\sigma_{f(\nabla)}$
G04	0.0141	0.0596	242	418	0.14
G05	0.0020	0.0452	171	228	0.31
G06	0.0004	0.1316	252	275	0.24
G09	0.0003	0.1171	183	239	0.22

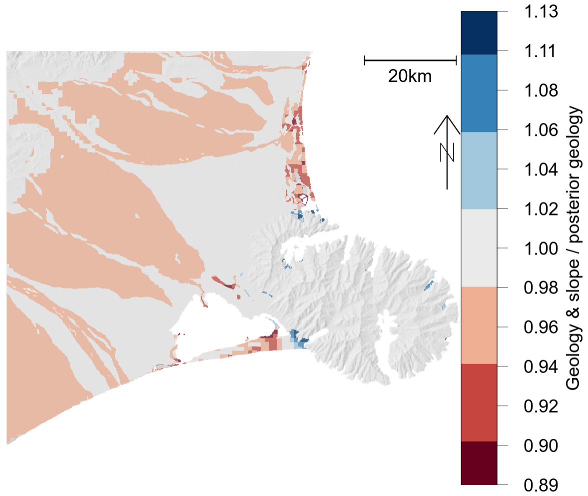

Figure 2.9: Ratio of slope+geology model (Figure 2.3c) to posterior geology model (not shown) median estimates. Note the small range on the graphic scale indicating much smaller model change by comparison with the posterior geology update.

In Bayesian parlance the application of slope correlations to the model is another instance of "updating," where a model is improved based on the use of data that were not accounted for beforehand. The posterior V_{S30} predictions are given by the piecewise-linear trends.

The results of slope-based correction represent a small change from the posterior geology model (by comparison with the prior geology model; compare σ values in Table 2.3 to those in Table 2.1). The slope-based V_{S30} and σ maps are visually indistinguishable from the posterior geology model, so only the log of the ratio of the two models' median V_{S30} predictions is presented here (Figure 2.9). The slope-updated geology model is shown in Figure 2.3c (V_{S30}) and Figure 2.4c (σ). Hereafter, we refer to this model as simply the "geology-based" model.

2.4.5 Comparing geology- and terrain-based models

Quantitative comparisons of the two posterior model predictions are presented in Figures 2.10 (mapped prediction comparison for all NZ) and 2.11 (per-datapoint residual comparison). In the map-based prediction (Figure 2.10), it is evident that the places where the models disagree most (*e.g.*, the volcanic Taupo &

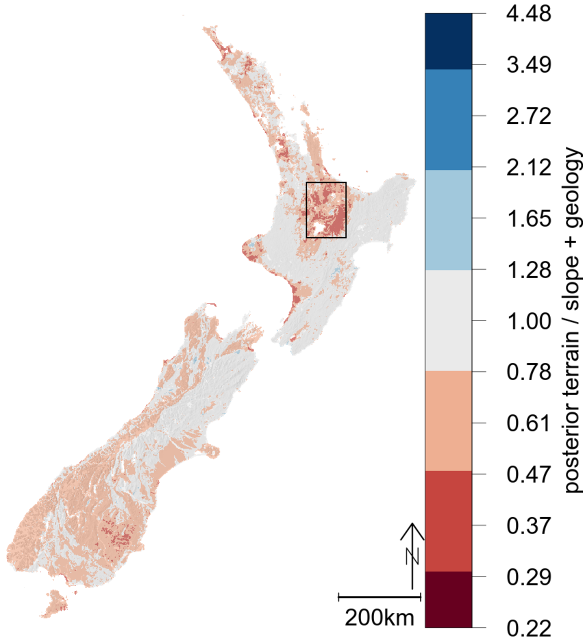

Figure 2.10: Map comparing median V_{S30} for posterior geology- and terrain-based models. The Taupo and Rotorua region (boxed) is an example of a region with unique interaction between the geology- and terrain-based categories that may merit prioritization for future field investigations.

Rotorua area in central North Island, indicated by a box in Figure 2.10) are places characterized by unique surface geology and geomorphology, and where there is consequently a unique pairing of geology and terrain categories. The model can benefit from data in these locations.

Figure 2.11 shows normalized geology and terrain model residuals $\boldsymbol{\zeta}$,

$$\zeta_i = \frac{\ln V_{S30_{\mathrm{obs.},i}} - \ln V_{S30_{\mathrm{pred.},i}}}{\sigma_i} \tag{2.2}$$

on the x- and y-axes respectively. σ_i values correspond to the values in Figure 2.4 (c and d). The residuals are roughly symmetrically scattered across the 1:1 line, suggesting that there is no systematic advantage of the geology-based model over the terrain-based model, or vice-versa, after Bayesian updating. Coloring of the points is by measured V_{S30} and highlights some biases in individual categories, particularly rock categories which are poorly represented.

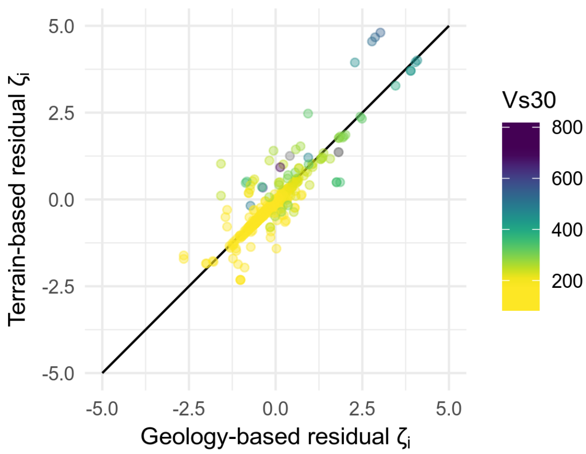

Figure 2.11: Scatterplot comparing V_{S30} residuals for posterior geology- and terrain-based models. Colored by V_{S30}.

2.5 Geostatistics application to posterior models

The geology and terrain models developed in the previous section predict V_{S30} as functions of surface geology, local topographic slope, and/or terrain proxy variables. A shortcoming of these models is that they do not offer improved predictions in the vicinity of existing measurements. The tool for addressing this issue is geostatistics. Two geostatistical approaches are applied to the geology and terrain models in this section. The first and simpler of the two is regression kriging (RK). The second is the so-called "multivariate normal" (MVN) method (Worden et al., 2018). Both methods are presented and discussed for comparative purposes; the MVN approach is ultimately chosen as the superior method for reasons discussed presently.

In the following sections, first a concise review is given of the broad aspects of geostatistical approaches, wherein quantifiable geospatial phenomena are modeled as stationary random processes, and the parameterization (*i.e.* variance and autocorrelation) of the stationary random processes are inferred from variogram analysis. Next the aspects of the MVN approach that depart from kriging, and its advantages for this work, are highlighted. Aspects of variogram and correlation function selection are discussed in the context of the V_{S30} map. The results of applying both RK and MVN are presented. The problem of interpolating/extrapolating residuals for a lognormal process such as V_{S30}, which can result in unreasonably high V_{S30} estimates in some situations, is discussed. Finally, we present two unique approaches we implemented to ameliorate these issues in a more-or-less automated way that requires few subjective decisions for implementation.

2.5.1 Preliminaries

This discussion follows notation from Diggle and Ribeiro (2007). The most common assumption underlying geostatistical methods is that spatial fluctuations in an earth science system (*e.g.* V_{S30}) can be modeled as a Gaussian random process, $S(\boldsymbol{x})$, a 2-dimensional function wherein a set of observations $S(\boldsymbol{x}_1, \ldots \boldsymbol{x}_n)$ for n locations $\boldsymbol{x}_1, \ldots \boldsymbol{x}_n$ is assumed to be drawn from a multivariate Gaussian (normal) distribution. A Gaussian random process is defined completely by its mean function $\mu(\boldsymbol{x}) = E[S(\boldsymbol{x})]$ and its covariance function $\gamma(\boldsymbol{x}, \boldsymbol{x'}) = \mathrm{Cov}\{S(\boldsymbol{x}), S(\boldsymbol{x'})\}$. If the mean is constant and the covariance structure is formulated solely as a function of distance (*i.e.* $\mu(\boldsymbol{x}) = \mu$ and $\gamma(\boldsymbol{x}, \boldsymbol{x'}) = \gamma(\boldsymbol{u})$ where $\boldsymbol{u} = \boldsymbol{x} - \boldsymbol{x'}$), then the process is known as the special case of a stationary random function (SRF). Usually SRF are also assumed isotropic, *i.e.* $\gamma(\boldsymbol{u}) = \gamma(||\boldsymbol{u}||) = \gamma(u)$ where $||\cdot||$ designates Euclidean distance. The variance of an SRF is constant: $\sigma^2 = \gamma(0)$. Hereafter we discuss only functions of scalar u rather than vector difference $\boldsymbol{u}$ as our application assumes isotropy as is typical for regional applications (*e.g.* Thompson et al., 2014).

For the stationary case, the variogram function is an alternative representation of the covariance function: $V(\boldsymbol{x}, \boldsymbol{x'}) = \frac{1}{2}\mathrm{Var}\{S(\boldsymbol{x}) - S(\boldsymbol{x'})\}$. This reduces to $V(u) = \sigma^2\{1 - \rho(u)\}$, where $\rho(u) = \frac{\gamma(u)}{\sigma^2}$ is the correlation function, again for the stationary case. The correlation function is 1 for $u = 0$ (for the typical application where the nonspatial component of randomness is zero) and decreases monotonically to approach zero asymptotically with increasing u.

The variogram is useful for both for interpreting observed spatial processes, and for generating predictions using models with SRF. The formulation above is known as the theoretical variogram. For using observational data to parameterize a geostatistical model, the sample variogram or empirical variogram can be obtained and then used to guide selection of the theoretical variogram. Observational data $\boldsymbol{Y}$ are assumed to be of the form $Y_i = S(\boldsymbol{x}_i) + Z_i$, where Z_i are mutually independent and identically distributed with zero mean and variance τ^2. The sample variogram is

$$V_Y(u_{ij}) = \frac{1}{2}\mathrm{E}[(Y_i - Y_j)^2], \tag{2.3}$$

and the functional form for fitting a theoretical variogram is

$$V_Y(u) = \tau^2 + \sigma^2\{1 - \rho(u)\}. \tag{2.4}$$

This formulation is more general than the one introduced above, with the addition of the τ^2 term.

The intercept, τ^2, is known as the nugget variance. It represents the non-spatial component of randomness in the process—requiring a dual interpretation of physical meaning, which we discuss presently to contrast conventional kriging with MVN. σ^2 is the signal variance. The asymptotic value, $\tau^2 + \sigma^2$, is known as the sill and is the variance of the observed process $Y(\boldsymbol{x})$. For the common special case of $\tau^2 = 0$ the sill is equivalent to the signal variance. The range of the variogram is the distance u beyond which there is no change in $V(u)$.

2.5.2 Empirical variograms

Two theoretical variograms, one each for the geology- and terrain-based models, are selected by fitting to empirical data. One of the simplest and most common functional forms is chosen for the theoretical variograms, the exponential model

$$V(u) = \exp(-\frac{u}{\phi}) \tag{2.5}$$

where ϕ, the range or shape parameter, has units of distance. The practical range, the value of u for which $\rho(u) = 0.05$, is approximately 3ϕ (Diggle and Ribeiro, 2007).

The empirical variograms here are produced with normalized residuals ($\boldsymbol{\zeta}_i$, Equation 2.2) in lieu of observations $S(\boldsymbol{x}_i)$ above. Normalization ensures homoscedacity of the residuals (*e.g.*, Jayaram and Baker, 2009) which is necessary to ensure the geostatistical assumption of Gaussian stationarity.

Because of the highly clustered nature of the available V_{S30} data, we explore several subsets of the data to assess the sensitivity of the fitted theoretical variogram to the data underlying the empirical variogram. The selection of subsets is motivated by a hypothesis that the large scale and relative spatial uniformity of the Canterbury plains—the largest alluvial deposit in NZ—may yield a variogram with a range that is longer than appropriate for other geographic regions. Thus we examine subsets with various degrees of exclusion of Christchurch and/or Canterbury V_{S30} data. These are summarized in Table 2.4.

Table 2.4: Data subsets used for variogram fitting.

Subset	Description	n	Weighting
GS1	Kaiser et al. (2017) Q1 & Q2; no Canterbury data	49	0.5
GS2	Kaiser et al. (2017) Q1 & Q2 and surface-wave-based data	127	0.25
GS3	McGann et al. (2017) data, (resampled to 1km)	266	0.25
TS1	Same as GS1 but with terrain categories T15 & T16 removed	29	0.5
TS2	Same as GS2 but with terrain categories T15 & T16 removed	42	0.5

Preliminary examination of the empirical variograms led us to conclude that the geology model yielded fairly "well-behaved" variograms while the terrain model variograms were considerably less smooth. We postulated that since the geology model incorporates continuously varying slope correction functions for a

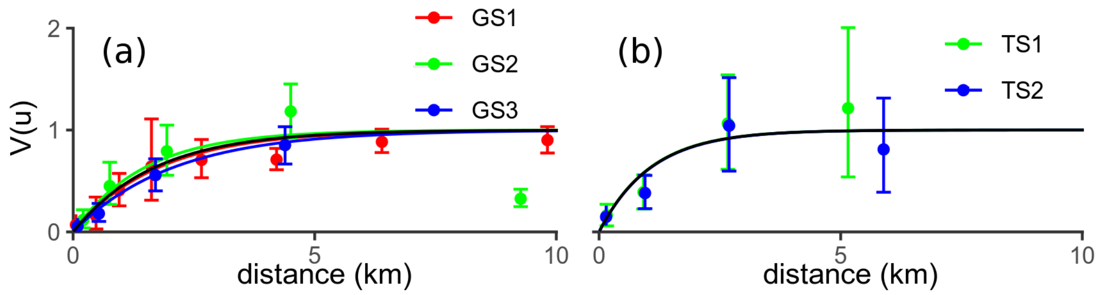

Figure 2.12: Theoretical variogram selection for (a) geology- and (b) terrain-based models.

few hand-selected geologic categories, whereas the terrain model subdivides regions based on discrete slope bins using the Iwahashi and Pike (2007) method, the latter might be showing some arbitrary stochasticity in the pairwise empirical variogram ordinates, particularly in categories T15 & T16 (which are the most prevalent in the Canterbury plains and other wide alluvial basins). The terrain subsets were modified by removing all points from terrain categories T15 & T16 and the resulting theoretical fits were improved.

The final selections for the geology- and terrain-based model variograms are summarized in Figure 2.12. For each of the five subsets, a logarithmically-spaced binning scheme was chosen and pairwise variogram ordinates were averaged within each bin to generate an unbiased estimator of the theoretical variogram. 95% confidence intervals obtained by bootstrapping are shown for each bin. The judgment-based weighting factors shown in Table 2.4 were used to fit one final exponential variogram each to the geology- and terrain-based models by weighted least-squares minimization (Pebesma, 2014). Notably, inspection of the plots reveals that the variogram is fairly insensitive to the data subsetting schemes we evaluated. The effective ranges for the geology and terrain variograms are 4.2 and 3.0 km, respectively. We note that since the variograms are calibrated to the normalized model residuals their differences are not necessarily attributable to physical meaning.

2.5.3 Kriging

"Predicting" unobserved values of a spatial process on the basis of geostatistics entails interpolating the observed values with interpolation weights derived from the variogram, and assuming that the mean of the process tracks the observed values. This process is known as kriging. Regression kriging (RK, *e.g.* Thompson et al., 2014) is an approach that makes the stationarity assumption useful for a wider variety of problems where the model mean $\mu = \mu(\boldsymbol{x})$ and is not constant across the problem domain. For RK, consistent with variogram development, the kriging is done on normalized observation residuals, ζ_i, assuming that the residual surface is the mean surface of a SRF.

The kriged geology- and terrain-based V_{S30} maps are shown in Figure 2.13. While the new V_{S30} estimates appear reasonable in general, we wish to highlight one location where this is not the case, a datapoint in Rakaia (identified by a box in Figure 2.13a). Here the geology model predicts unrealistically high V_{S30} values because a high-valued observation (presumably reflective of loess deposits, category G11) appears to be located near a geologic boundary on a lower-valued polygon (G06 or G13) yielding a higher normalized residual than may be appropriate. The smoothed residual surface is multiplicative rather than additive, owing to the lognormal assumption, and consequently exerts a great influence over the area. (A tiny region in the vicinity of this error is colored gray indicating the color scale is "clipped," *i.e.* the model predicts a median V_{S30} in excess of 1000 m/s.)

This issue is exemplary of geostatistical problems that may occur wherever observational data happen to be located on the "wrong side" of a high contrast geologic boundary (between cemented loess and unconsolidated sediments in this example, or between rock and soil generally). In the next section we propose a novel method of handling such errors that is effective at reducing undesirable cross-boundary extrapolation in lieu of the time-consuming and subjective alternative approach (*i.e.* manually identifying and relocating problematic observations or map boundaries wherever this issue arises).

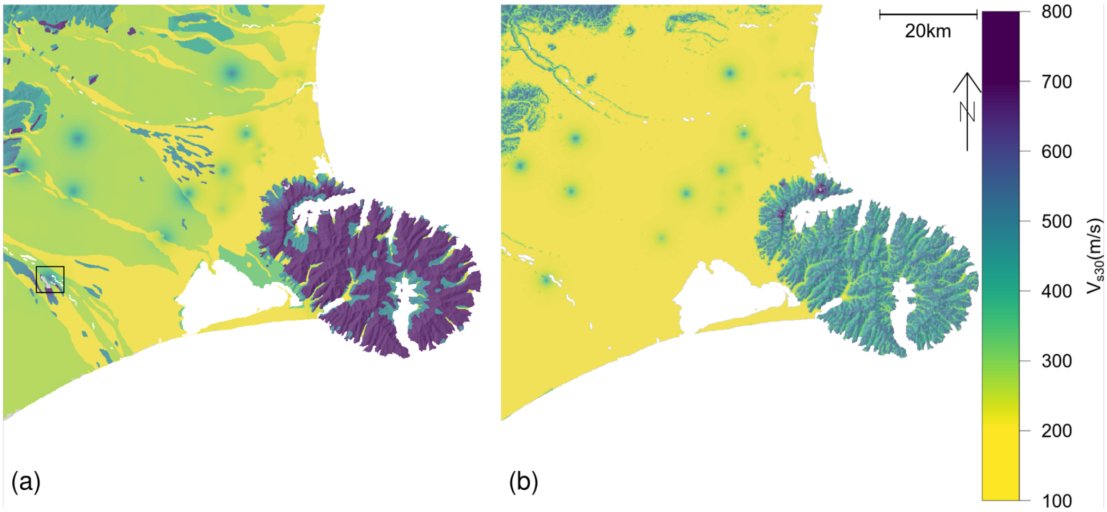

Figure 2.13: The kriged V_{S30} maps for the (a) geology- and (b) terrain-based models. An example of potentially inappropriate extrapolation across geologic boundaries is visible in the Rakaia area (boxed).

The kriged uncertainty (σ) maps are shown in Figure 2.14 and, as expected, approach zero near measurements because the nugget of the variogram is zero. The "background" σ, in regions where there are no nearby observations, reverts to the input σ (*i.e.* Figure 2.4).

The kriged residual in Figure 2.14 suggests that the baseline model may systematically underpredict V_{S30} in the Canterbury plains, west of Christchurch city. This is not unexpected; in the simplified geology categories (Figure 2.5a) there is no discrimination between the surface geology beneath Christchurch and in the plains to the west. But the geology of the coastal basin consists of interbedded layers from alternating deposits of river/alluvial and marine deposits which may suggest that surface geology alone (presuming it is representative of less than 30m depth) is inadequate as a proxy for V_{S30}. This dilemma with young alluvial deposits is common for V_{S30} estimates that rely on surface geology (*e.g.* Wills and Gutierrez, 2009).

Related to this issue is the dominance of the Christchurch city data. An alternative approach would be to generate another model by choosing sparser sampling distance for the Christchurch data and thereby decreasing the weight accorded to urban data. Ultimately this decision represents a tradeoff that should be informed

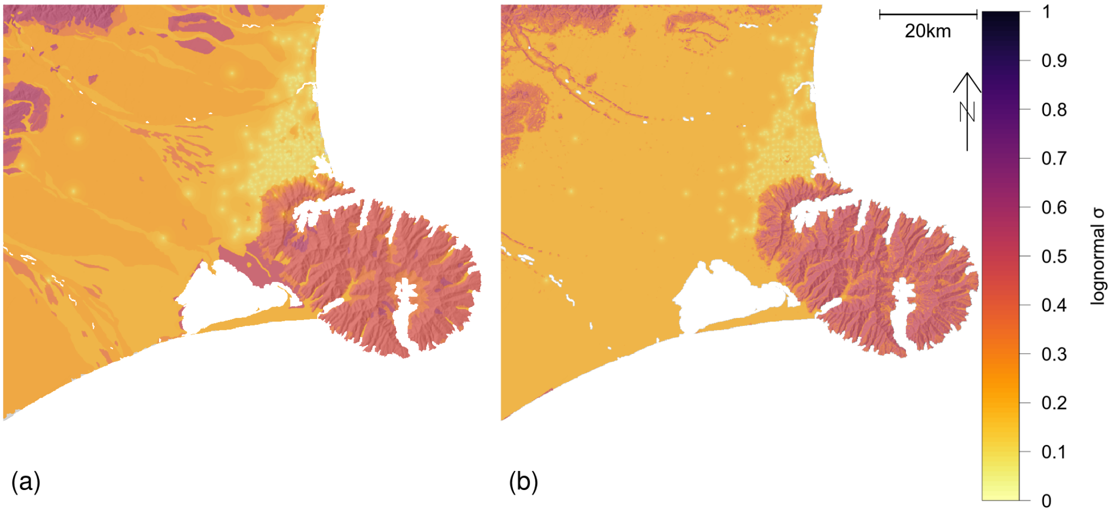

Figure 2.14: The kriged σ maps for the (a) geology and (b) terrain-based models. Lower uncertainty corresponds to locations of V_{S30} data (Figure 2.2).

by application. Our view is that V_{S30} data density is generally correlated with population density for good reason, and that for engineering applications it is acceptable to allow data to drive the model, irrespective of the unavoidable spatial clustering.

2.5.4 MVN (Multivariate Normal) method

Worden et al. (2018) present a more generalized geostatistical approach than kriging, which we refer to as the "multivariate normal" (MVN) method. The primary advantage of this method in our work (compared with RK) is that it allows for assumptions about measurement uncertainty to be applied on a location-by-location basis.

In conventional kriging, if the nonspatial component of variance—the nugget—is zero, then the interpolated mean surface is constrained so as to match the observational values at their respective locations. A nonzero nugget means the interpolated surface need not honor the data precisely. The nonzero nugget has a dual physical meaning: On the one hand, the tendency of the modeled system to exhibit spatial discontinuities; and on the other hand, measurement uncertainty. In practice these causes are rarely disentangled, because many collocated measurements would be required. A nonzero nugget in the variogram is formally equivalent to modeling the measurement process as a Gaussian spatial process with a discontinuity at the origin of the correlation function. But importantly, in conventional kriging, a nonzero nugget is the same across the problem domain. By contrast, in the MVN approach, explicit assumptions about measurement uncertainty are enforced via "correlation adjustment factors" that can be assigned to measurements on an individual basis. The output σ can be different at different data points, in accordance with the respective input measurement uncertainties. Correspondingly, individual observations exert a "pull" on the interpolated surface that is inversely correlated with measurement uncertainty. The variogram nugget is thus effectively localized for data from different sources. (The MVN results reduce to being equivalent to the kriging results with zero nugget for the special case where all measurement uncertainties are set to zero).

We assigned each input datum a lognormal measurement uncertainty, $\sigma_{\text{meas.}}$. These values were chosen following the discussion in Section 2.3 and are tabulated in the electronic supplement. Assigning $\sigma_{\text{meas.}}$ is not trivial or objective (*e.g.,* McElreath, 2015). However, given that measurement uncertainty is a "nuisance parameter" in the parlance of Gelman et al. (2014, pp. 63-64), it is intuitive to expect that the chosen value of $\sigma_{\text{meas.}}$ becomes insignificant in regions of dense data (*e.g.* Christchurch city) and therefore impacts the model most strongly in regions with little data. Moreover, this framework allows for future model refinements on the basis of more and better observational data.

2.5.4.1 Correcting overpredictions from cross-boundary extrapolation

The issue of "cross-boundary extrapolation" was discussed earlier as it pertains to regression kriging. Here we propose a novel solution that entails modifying the correlation function $\rho(u)$ for every unique pairwise combination of locations in the problem domain. Toward this end, a coefficient is introduced, the "covariance reduction factor" (CRF) with a value between 0 and 1. The CRF is a function of the "difference" between two points of interest. Qualitatively, in this context "difference" implies the appropriateness in general of assuming nonzero correlation between two locations, irrespective of their separation distance. Quantitatively, $0 \leq \text{CRF} \leq 1$.

A proxy variable needs to be selected for choosing CRF given two locations, $\boldsymbol{x}_1$ and $\boldsymbol{x}_2$. We chose the ratio of the two corresponding model V_{S30} predictions, since this reflects the most pertinent information contained in both the geology- and terrain-based models. Alternatives could be chosen, for example the ratio of slopes alone, or a more complex assessment of the geologic map. The function for CRF is chosen as

$$\text{CRF} = \exp\left(-a \left| \ln \frac{V_{S30_1}}{V_{S30_2}} \right|\right) \tag{2.6}$$

which ensures $\text{CRF} = 1$ for $V_{S30_1} = V_{S30_2}$ with exponential decay as the ratio of the baseline V_{S30} estimates decreases. We selected $a = 1.5$ based on the heuristic that the decay function ought to yield $\text{CRF} \approx 0.1$ (*i.e.* almost no correlation) for the ratio $\frac{V_{S30_1}}{V_{S30_2}} \approx 5$; see Figure 2.15. This corresponds to an arbitrary reference hypothetical where $V_{S30_1} = 1000$m/s and $V_{S30_2} = 200$m/s, *i.e.* "rock" and "soil." This heuristic is necessarily arbitrary and reflects an intuition about the complexity of geologic processes that depart from idealized assumptions underlying geostatistical methods. While there are alternative approaches to representing this complexity, the proposed method appears to handle the issues well globally and relies on the selection of only a single parameter. This is desirable for updating the model in a more or less automated fashion in the future, as additional data are incorporated into the model.

To apply the above modification to the MVN method, CRF is computed in accordance with Equation 2.6. Then Equation 7 from Worden et al. (2018) is adjusted by defining a modified correlation coefficient:

$$\rho'_{Y_iY_j} = \rho_{Y_iY_j}\text{CRF}_{Y_iY_j} \tag{2.7}$$

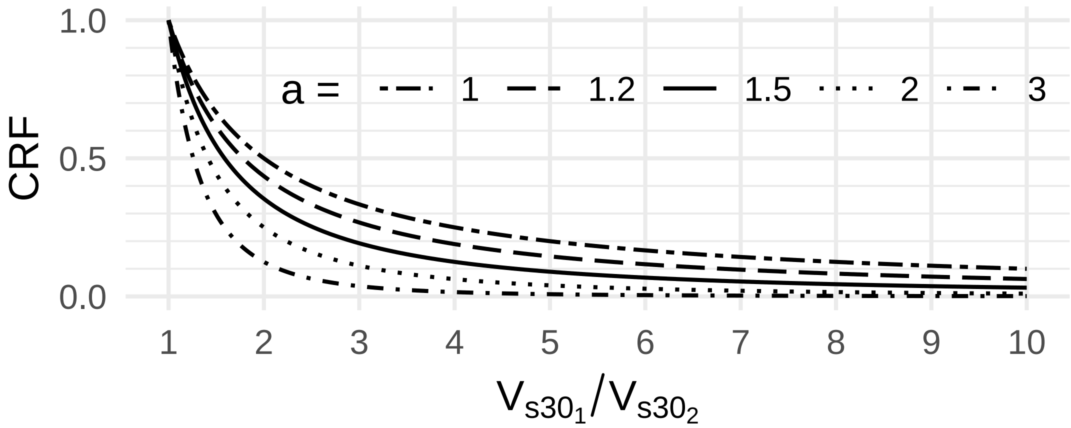

Figure 2.15: Several example covariance reduction functions.

2.5.4.2 Results

The result of the covariance-weighted MVN applications are presented in Figure 2.16. The ratios of Figure 2.16 to the regression kriging models (Figure 2.13) are shown in Figure 2.17. σ for the covariance-weighted MVN model is shown in Figure 2.18.

Three items are noteworthy in comparing the performance of the RK and MVN methods (Figure 2.17):

1. In regions where data are dense, such as Christchurch city, the models yield virtually the same predictions. The collocation of many V_{S30} datapoints results in a smoothing effect whose details are largely unchanged by the addition of measurement uncertainty.
2. In regions where data are sparse, such as the rural Canterbury plains, the models are slightly different in the vicinity of data because of the way RK and MVN differ in handling measurement uncertainty. The baseline V_{S30} estimate (geology or terrain model) has no effect at the precise location of an observation for RK, whereas the observation and baseline model estimates are combined in the MVN method, with the proportional influence being a function of the assumed measurement uncertainty.
3. The localized overprediction in the Rakaia area, noted previously, has been

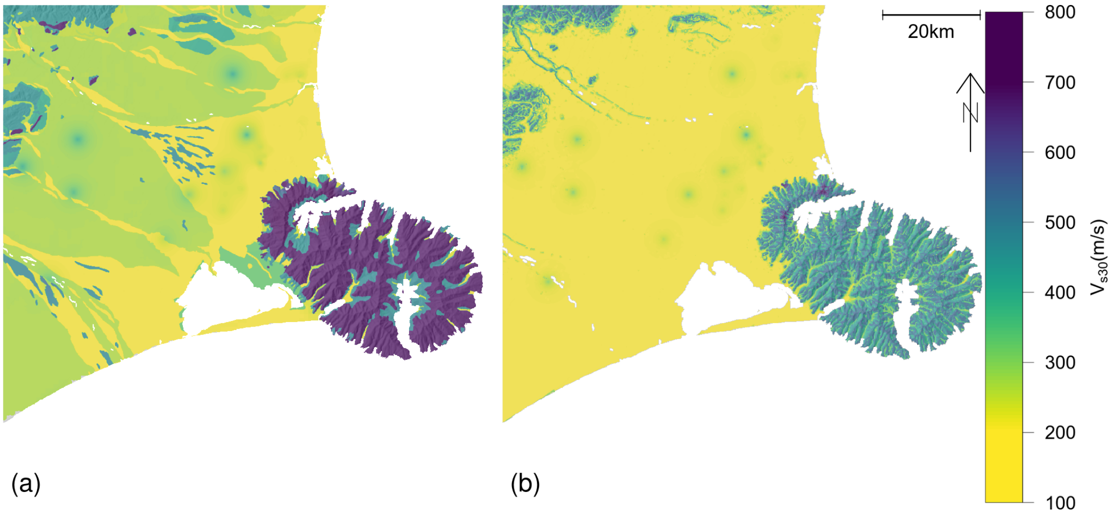

Figure 2.16: Covariance-adjusted MVN model V_{S30} estimates for (a) geology- and (b) terrain-based models. The overprediction noted in the regression kriging (Rakaia area, Figure 2.13) is eliminated.

resolved by the MVN method. The different degrees of covariance applied across the geologic boundaries in this area are clear in Figure 2.17(a).

2.6 Merging geology & terrain models

To summarize the preceding discussion, the MVN method is more general and more statistically sound than regression kriging because it allows pointwise assignment of measurement uncertainty, albeit at the expense of longer computation time. The "covariance reduction" method proposed above is a transparent and automated way of handling potentially misleading extrapolation of normalized residuals across geologic boundaries. Consequently we present the MVN model versions as superior to the more conventional regression kriging results. In this section we combine the geology- and terrain-based models into a final model.

Having conditioned each constituent model on available data, and applied geostatistical interpolation, we see no reason to favor one model over the other and assign each a weighting of 0.5. The decision to weight the two models equally, rather than favoring one over the other, is motivated by the assumption that

Figure 2.17: Covariance-adjusted MVN model V_{S30} predictions compared with regression kriging (RK) predictions for (a) geology- and (b) terrain-based models.

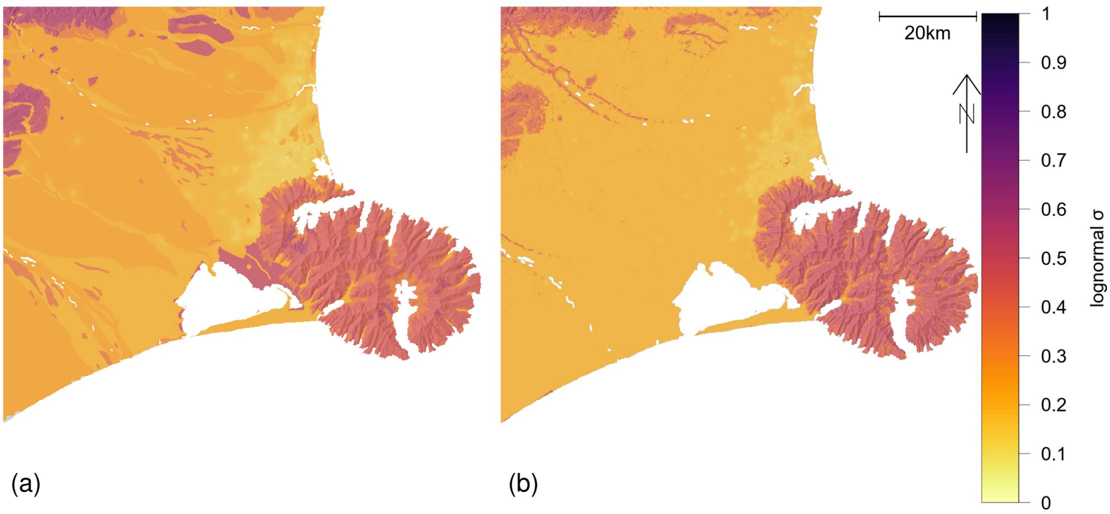

Figure 2.18: Covariance-adjusted MVN model σ for (a) geology- and (b) terrain-based models.

aspects of the geology- and terrain-based approaches are mutually complementary. For example, the geology categories can convey information pertaining to V_{S30} that may not be readily discriminated by the terrain categories, but the terrain data are more spatially uniform, less subject to human interpretation, and may indicate finer detail in local V_{S30} variations and/or more accurate velocity contrast boundaries, particularly in areas where the geology map is derived from digitizing older regional-scale maps.

The weighting is done as

$$V_{s,30_{\text{final}}} = \exp\left(\sum_{i=1}^{n} w_i \ln V_{s,30_i}\right) \tag{2.8}$$

where in general $\sum_i w_i = 1$ and in the present application (combining two equally-weighted models), $n = 2$, $w_1 = w_2 = 0.5$. The combining of uncertainty represents a "mixture problem:" If the constituent models predict similar V_{S30} and have small σ then the resulting σ is a compromise between the two input σ values. On the other hand if the two models predict significantly different V_{S30} values then the combined uncertainty is high, even if the constituent models have low σ:

$$\sigma^2_{\text{final}} = \sum_{i=1}^{n} w_i \left(\left(\ln V_{s,30_i} - \ln V_{s,30_{\text{final}}}\right)^2 + \sigma_i^2\right) \tag{2.9}$$

where again $n = 2$, $w_1 = w_2 = 0.5$. Once more, this is functionally equivalent to Bayesian updating with equal weighting of "prior" (geology-based model) and "data" (terrain-based model) (e.g., McElreath, 2015). The weighted, final model median V_{S30} estimate and lognormal σ are presented in Figure 2.19.

2.7 Conclusion

A V_{S30} model for NZ has been developed. The salient features of the model include a fine (100m) resolution; making use of both geology and terrain covariates; a consistent, local V_{S30} data inclusion via transparent and readily updateable

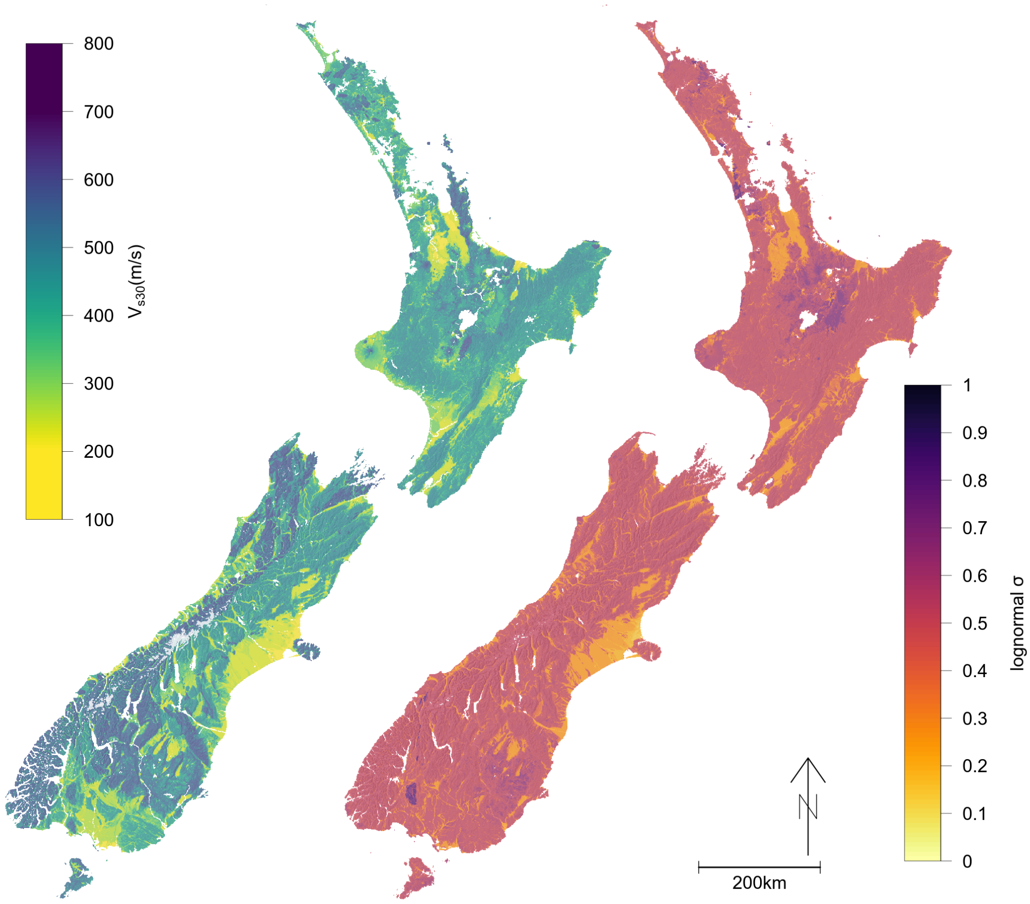

Figure 2.19: (a) V_{S30} and (b) σ for the final weighted model.

Bayesian framework; lognormal standard deviations alongside median V_{S30} estimates; and a novel modification to the MVN method (Worden et al., 2018) that reduces covariance for observation-prediction pairs that cross geologic/geomorphic boundaries, yielding heuristically sensible V_{S30} estimates near these boundaries. The model represents an improvement over recent V_{S30} models for New Zealand which have used geology proxy variables but have not quantified uncertainty or employed geostatistical methods.

The model can be updated relatively easily and it is expected that recent field work performed in Nelson, Auckland and Wellington will be incorporated into an incremental update in the near future.

The code repository for this work is available on GitHub at https://github.com/fostergeotech/Vs30_NZ.

2.8 Data and Resources

All data used in this paper came from published sources listed in the references, with the exception of the V_{S30} values from Wood et al. (2011) which, as noted previously, have been adjusted in the present work based on review of the dispersion curve interpretation which is unpublished. The tabulated V_{S30} values in the electronic supplement corresponding to the Wood et al. (2011) work are not the same as the original published work.

2.9 Acknowledgments

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Chapter 3

Validation of V_{S30} Estimation Using the "P-wave Method" at Strong Motion Stations in New Zealand

Abstract

Recent studies have used the continuum mechanical solution for the arrival of a P-wave at the surface of an elastic half-space to estimate shear wave velocity V_S near the surface using small earthquake recordings, and thence (via empirical correlations) V_{S30}. This approach requires as inputs the ratio of the radial and vertical components of ground velocity ($\frac{\dot{U}_R}{\dot{U}_Z}$) during the first P-wave arrival, and the ray parameter p. The latter is estimated using a regional-scale velocity model simplified to a two-layer, one-dimensional profile, and finding the location of refraction that minimizes travel time for the first arrival. In the present study the so-called "P-wave method" is applied to strong motion stations in New Zealand with V_{S30} measurements.

Since many stations have plentiful recordings of small earthquakes, a semi-automated approach to ground motion processing is desired. A sub-

set of ground motions are selected for manual examination and used as a benchmark for validation of automated pulse-picking methods. Since the P-wave method uses the velocity (rather than acceleration) traces, baseline drift (nonzero local average velocity owing to cumulative integration of high- and/or low-frequency noise) is an issue. Automated methods for pulse-picking are effectively blind to baseline drift and may yield meaningless results. Some previous studies have been applied in relatively low-seismicity regions and hence the drift problem has been amenable to manual processing or culling. In this study, some effort is dedicated to assessing the degree to which an automated "local baseline correction" approach reduces the quality of V_{S30} estimates by comparison with manual processing and culling, and how this changes bias and variance.

Another avenue of investigation is the impact of one- versus two-dimensional representations of the regional velocity profiles used to generate V_{S30} estimates. We demonstrate that if it is available, using a more detailed two-dimensional "slice" representation yields a significant benefit in terms of precision and accuracy of V_{S30} estimates. This is a unique contribution to the approach, although it can only be applied in regions where sufficiently detailed regional-scale P-wave velocity models are available.

Finally, some tentative investigations into the limitations of the P-wave method are presented. These focus on the degree to which the real world departs from the idealised representations assumed by the P-wave method, and how such departure can be quantified using information at hand, such as surface topography and the phase characteristics of the first radial and vertical wave arrivals. These investigations are rendered inconclusive by the small number of strong motion stations in New Zealand with V_{S30} measurements for validating the P-wave method.

3.1 Introduction

The ratio of horizontal to vertical (H/V) components of ground motions (both ambient noise and weak earthquake records) has been used widely to obtain simple characterization of, or place constraints on, the near-surface elastic parameters of soil (P-wave velocity V_P and shear wave velocity V_S). This approach has generally used the frequency-dependent ratio obtained from long duration recordings of ambient noise and assumed that most ambient vibrations are Rayleigh waves (H/V method, Nakamura, 1989), or used the S-wave portions of weak earthquake records (Lermo and Chávez-García, 1993). Ni et al. (2014) introduced a method ("the P-wave method" herein) as a simplified adaptation of spectral methods (*e.g.*, Arai and Tokimatsu, 2004), using the instantaneous H/V ratio of the very earliest isolated, initial P-wave arrivals of weak earthquake records to estimate V_{SZ}, the subsurface shear wave velocity over a representative depth z roughly proportional to wavelength. Ni et al. (2014) demonstrated that this instantaneous H/V ratio is both sensitive to V_{SZ}, and relatively insensitive to P-wave velocity, using synthetic seismograms generated for prototypical site profiles with prescribed source mechanisms. They also demonstrated good performance of the P-wave method for a record from the 18 April 2008 Mt. Carmel earthquake sequence. Li et al. (2014) applied the method to a recording of the 2011 M_{W} 5.8 Mineral, Virginia earthquake and found good agreement with field measurements. These studies were uniquely the first to investigate the application of the P-wave method to the problem of geotechnical site characterisation, as opposed to the purely seismological applications of earlier studies.

Kim et al. (2016) applied the P-wave method to 31 stations in Central & Eastern North America (CENA) from several seismic networks with recordings of 106 earthquakes collectively. The ray parameter, p, was estimated assuming a simple one-dimensional (1D) velocity model (EPRI, 1993). Estimates of the time-averaged shear wave velocity for vertical travel through the uppermost 30 metres (V_{S30}) were obtained for each site by developing and applying empirical correlations between V_{SZ} and V_{S30}. The resulting residuals exhibited lower bias and variance than for V_{S30} estimated from other common proxy-based (geology, slope, terrain) methods. Hosseini et al. (2016) applied the P-wave method to a number of stations in the ANSS and EarthScope networks in the Central &

Eastern United States (CEUS). The earthquake records they used spanned five years and about 560 stations.

Zalachoris et al. (2017) applied the P-wave method to 251 stations located in the plains region of the United States (in Texas, Kansas, and Oklahoma) and compared the distributions of the resulting V_{S30} estimates with a proxy geology-based model by Parker et al. (2017). Results were mixed; the authors postulate differences between the two models (particularly for soil sites) may have arisen because of differences in alluvium thickness at sites examined in the two studies. Miao et al. (2018) applied the method at 298 sites in Japan. They found better performance there than the Kim et al. (2016) in CENA, citing a more precise crustal model for Japan, although both studies (as well as Zalachoris et al., 2017) used one-dimensional crustal models.

Kang et al. (2020) applied the P-wave method to a much larger set of ground motions from the K-net network in Japan. More than 9,000 records were processed for 630 stations. They handled baseline drift automatically with a local baseline correction (LBC) method. They also identified a bias in V_S estimates that is correlated with takeoff angle (inclination of the first arriving wave as it leaves the hypocentre).

The goals of the present work were to assess the accuracy of the P-wave method for sites in New Zealand with field measurements of V_{S30}; to determine whether better V_{S30} estimates can be obtained by using detailed two-dimensional profiles or "slices" of of basin velocity models in New Zealand (Thomson et al., 2020) in contrast to the 1-D approaches in prior studies; to empirically validate the appropriateness of automated picking and LBC (Kang et al., 2020) for processing ground motions; and to explore whether simple criteria can be identified for assessing whether a particular strong-motion site is well-suited to V_S estimation by the P-wave method (either 1-D or 2-D variants).

The remainder of this chapter is organized in the following way. Section 3.2 briefly introduces the theoretical formulation of the problem of estimating V_{S30}

from H/V ratios. Section 3.3 summarizes the New Zealand strong-motion stations selected for evaluation and the how salient ground motion parameters (pulse peak picking, signal-to-noise ratio [SNR] criteria, *etc.*) were obtained. Sections 3.4 and 3.5 discuss approaches to obtaining the ray parameter and H/V ratios, respectively; these are the main parameters needed to estimate V_S. The proposed improvement to the ray parameter estimation using two-dimensional velocity profiles is also explained in Section 3.4. The results are presented in Section 3.6. A correction for prediction bias as a function of takeoff angle is given in Section 3.7. Some discussion on the problem of deciding whether a given strong motion station site is appropriate for applying the P-wave method is provided in Section 3.8.

3.2 Theory/formulation

Aki and Richards (2002) provide the solutions for the vertical and radial components of ground displacement for a plane P-wave arriving at the surface of an elastic half-space with uniform elastic properties (Figure 3.1). From these the equation for the ratio of the velocities can be derived; the equation as presented in Li et al. (2014) is

$$\frac{\dot{U}_R}{\dot{U}_Z} = \frac{2V_S p \cos j}{1 - 2p^2 V_S^2} \tag{3.1}$$

where $\dot{U}_R$ and $\dot{U}_Z$ are respectively the radial and vertical components of particle velocity at the surface of the half-space, V_S is shear wave velocity, p is the ray parameter, and j is the angle of the reflected shear wave with respect to vertical (Figure 3.1).

The ray parameter p is an invariant property of a travelling seismic ray that remains constant for every reflection and refraction along the travel path. It is defined as

$$p = \frac{\sin i}{V_P} = \frac{\sin j}{V_S} \tag{3.2}$$

where V_P and V_S are the P- and S-wave velocities of the materials at a reflecting/refracting boundary; i is the angle (from vertical) of an incident, reflected or transmitted P-wave; and j is the angle of a converted/generated SV-wave.

From the Pythagorean Identity ($\sin^2\theta + \cos^2\theta = 1$) and Equation 3.2 it can be deduced that

$$\cos j = \sqrt{1 - V_S^2 p^2}. \tag{3.3}$$

This expression for $\cos j$ can be substituted into Equation 3.1. If $\cos j > 0$, this implies that $\mid j \mid < 90°$ which is consistent with a half-space, so the negative root in Equation 3.3 does not need to be considered. Solving for V_S (Li et al., 2014):

$$V_S = \frac{1}{p}\sqrt{\frac{1 - \sqrt{\dfrac{1}{1 + \left(\dfrac{\dot{U}_R}{\dot{U}_Z}\right)^2}}}{2}}. \tag{3.4}$$

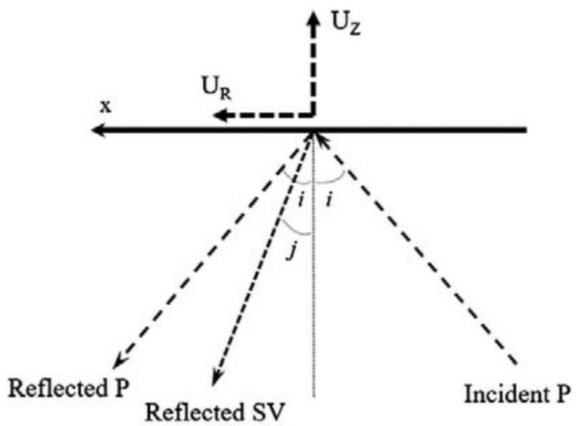


Figure 3.1: A P-wave arriving at the ground surface, generating a reflected downgoing P-wave and a converted S-wave. (From Zalachoris et al., 2017)

A few variations on this formulation occur in the literature. After the formulation proposed by Li et al. (2014) (Equation 3.1), others (Kim et al., 2016; Miao et al., 2018; Kang et al., 2020) found V_S by iteratively computing j as $\sin^{-1}(pV_S)$ (Equation 3.2) until Equation 3.1 converged on a single value of V_S. The two approaches yield the same result, but it is worth noting that iteration can be avoided. In deriving Equation 3.4 from Equation 3.1, a decision is required about the sign of the inner radical; this is discussed in Appendix D in terms of its influence on V_S.

The solution by Aki and Richards (2002) assumes a half-space with uniform elastic properties. For the real earth, the V_S value above is assumed representative along a distance of one wavelength of an S-wave, z meters (V_{SZ}, $z = \tau_p V_{SZ}$) where τ_p is the pulse duration of the source time function. Following Ni et al. (2014); Kim et al. (2016), and others, we assume $\tau_p = 0.1$s which is typical for the range of magnitudes considered. Finally, an empirical relationship between V_{SZ} and V_{S30} (Kim et al., 2016) is used to estimate V_{S30}.

3.3 Stations, records and preprocessing

Strong motion stations with existing V_{S30} data and/or V_S profiles were selected. Most of these are from surface wave testing (Cox and Vantassel, 2018; Kaiser et al., 2017). The stations examined are summarized in Table 3.1.

Ground motions for this study were retrieved from the GeoNet FDSN network server. The service does not enforce explicit event-record associations, so available records were associated with their causal earthquakes based on a time window corresponding to event times in the earthquake catalog. A catalog for each station was compiled, consisting of events occurring between 2000-01-01 and 2015-01-01, magnitudes from 3.0 to 5.0 and within a 200km radius of each station. Only strong-motion records sampled at 200Hz (SEED channel code `HN?`) were used (Ahern et al., 2012; GeoNet, 2020).

Based on event metadata and station location, each ground motion recording was associated with a theoretical arrival time (t_{TAT}) computed using the TauP algorithm (Crotwell et al., 1999) as implemented in the ObsPy toolkit (Beyreuther et al., 2010), assuming the one-dimensional (spherical) earth model by Kennett et al. (1995). Each three-component raw acceleration record was demeaned, and the `ar_pick` method (Akazawa, 2004) as implemented in ObsPy was used to pick the P-phase arrival time (t_{pick}). This algorithm employs the well-known STA/LTA (short-term average / long-term average) ratio[1] as well as an Akaike Information Criterion (AIC)-based autoregressive modelling approach,[2] giving fairly robust performance in picking of various seismic phases.[3]

The horizontal components of each record were rotated to the radial and tangential directions relative to source azimuth, and pre-event noise was removed such that the maximum of either five seconds, or five percent of the trimmed record, remained before the theoretical arrival time. Signal to noise ratio (SNR) was computed for each component of each ground motion record using both amplitude- and energy-based measures (SNR_A and SNR_E respectively) (Lee et al., 2014). The noise and signal windows were taken as one second immediately preceding and following t_{pick}. Records with $\mathrm{SNR}_A < 2$ or $\mathrm{SNR}_E < 10$ were discarded (these were arbitrary thresholds for removing the most obviously unusable recordings; presently SNR is examined more closely). The geometric mean of the maximum SNR_A and maximum SNR_E was saved for each component, and the lowest of these three was retained for each record. This quantity is referred to simply as SNR hereafter. The distributions of SNR per station are summarised in Figure 3.2.

Filtering and baseline correction were performed according to recommendations by the U.S. Geological Survey (2012), Boore (2005), and Boore and Bommer (2005), with filtering corner frequencies of 0.02 and 50 Hz (Robin Lee, pers. comm.)

[1]STA/LTA processing relies on the insight that a sudden spike in an otherwise stationary random signal will register as an increase in a short-term windowed average of the signal above a longer-term windowed average. The length of the time windows can be chosen as model parameters. Properly tuned STA/LTA triggering algorithms have the advantage of relatively scale-invariant performance so that phase arrivals in both high- and low-noise signals can be detected.

[2]essentially, splitting a timeseries into two segments, varying the timestep of the split to search for best candidate phase arrival time, and using AIC to optimize the performance of a statistical model representing the expected pre- and post-phase-arrival signal characteristics

[3]*P*-phase picking is a trivial problem compared with other seismic phases (*e.g.* *S*-wave and surface wave arrivals) because, being the first seismic waves to arrive at a recording station, they are not obscured by motions produced by earlier seismic phases. The `ar_pick` results were spot-checked to confirm satisfactory performance. No attempt was made to perform an exhaustive review of phase picking algorithms. It is likely that a number of other algorithms would have yielded similarly good performance. In any case, a significant collection of ground motions were processed with manual pulse picking (Section 3.5.1) because it is understood that no algorithm can be expected to perform perfectly.

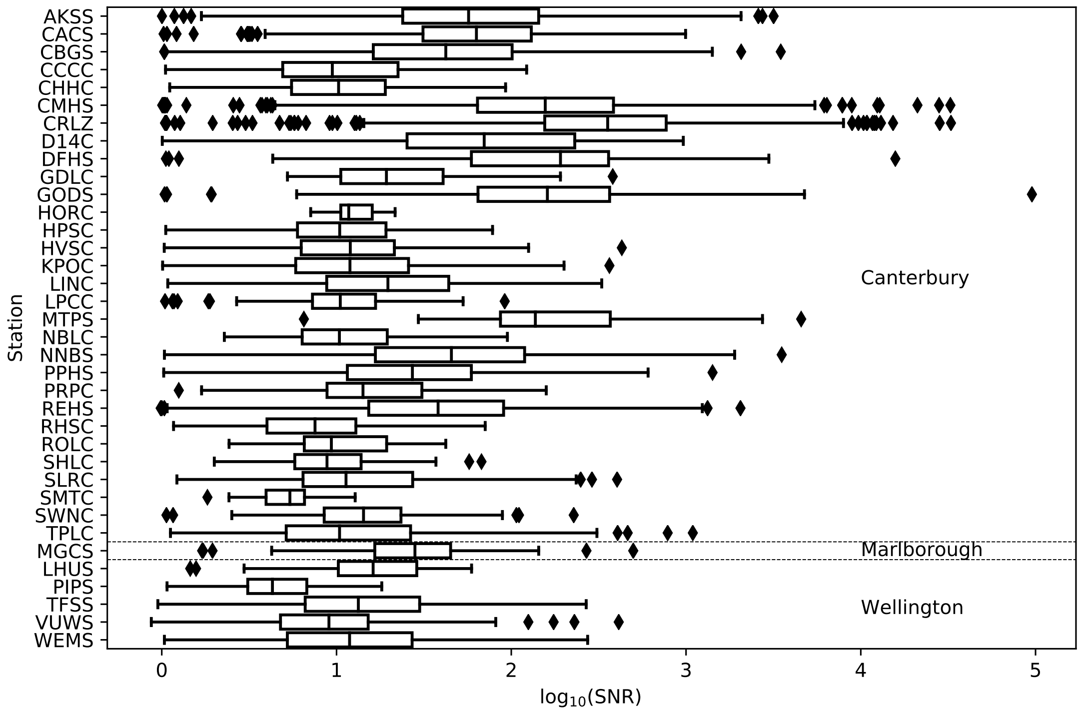


Figure 3.2: Distribution of signal-to-noise ratio SNR per station.

Table 3.1: Summary information for sites examined. D_1: distance from major impedance contrast to ground surface (Figure 3.3). N_{raw}: number of ground motion records for the station. N_{SNR}: number of records above SNR=1.6 (Discussed in Section 3.6.1). N_{manual}: number of records with manual inspection (Section 3.5.1). Fea: Foster et al. (2019). SW: surface wave based measurements. Superscripts indicate data source as follows: a: Wood et al. (2011); b: Wotherspoon et al. (2013); c: Van Houtte et al. (2014); d: Wotherspoon et al. (2016); e: Kaiser et al. (2017); f: Cox and Vantassel (2018); g: Teague et al. (2018); h: Andrew Stolte (pers. comm.) Regions: C=Canterbury; M=Marlborough; W=Wellington.

ID	Site name	Region	D_1 (m)	N_{raw}	N_{manual}	N_{SNR}	$V_{S30,\mathrm{Fea}}$ (m/s)	$V_{S30,\mathrm{SW}}$ (m/s)
AKSS	Akaroa School	C	805	453	110	276	265	1073[c],435[e]
CACS	Christchurch Canterbury Aero Club	C	1673	508	106	340	374	435[b],435[e]
CBGS	Christchurch Botanic Gardens	C	1798	974	117	501	193	197[b],197[e]
CCCC	Christchurch Cathedral College	C	1905	173	78	19	183	177[b],182[e]
CHHC	Christchurch Hospital	C	1802	160	78	8	194	206[b],196[e]
CMHS	Christchurch Cashmere High School	C	1471	1320	109	1112	203	205[b],213[e],222[g],222[g]
CRLZ	Canterbury Ring Laser	C	1386	1056	104	972	804	900[c]
D14C	Kennedy Bush Reserve	C	758	72	58	47	698	733[c]
DFHS	Darfield High School	C	1205	272	100	229	345	518[d]
GDLC	Greendale	C	1657	49	40	13	331	457[d]
GODS	Godley Drive	C	1724	527	95	451	611	586[c]
HORC	Hororata School	C	2059	5	4	0	349	531[d]
HPSC	Hulverstone Drive Pumping Station	C	1909	236	85	18	194	207[b]
HVSC	Heathcote Valley Primary School	C	1481	458	90	49	351	352[b],348[e]
KPOC	Kaiapoi North School	C	1886	278	98	50	244	257[b],257[e]
LINC	Lincoln Crop and Food Research	C	913	187	96	54	240	292[d]
LPCC	Lyttelton Port Company	C	1044	164	76	6	471	792[a]
MTPS	Mount Pleasant	C	1854	81	76	75	764	830[c]
NBLC	New Brighton Library	C	1918	145	83	12	192	190[b],189[e]
NNBS	Rawhiti School	C	1929	550	117	292	198	212[b],204[e]
PPHS	Christchurch Papanui High School	C	1771	623	114	241	180	187[b],180[e]
PRPC	Pages Road Pumping Station	C	1941	312	96	56	194	196[b],196[e]
REHS	Christchurch Resthaven	C	1874	683	112	333	165	154[b],155[e]
RHSC	Riccarton High School	C	1474	226	77	5	268	286[b],286[e],324[g],324[g]
ROLC	Rolleston School	C	1321	37	35	1	291	447[d]
SHLC	Shirley Library	C	1897	95	61	2	197	210[b],201[e]
SLRC	Selwyn Lake Road	C	1091	444	106	77	252	327[d]
SMTC	Styx Mill Transfer Station	C	1889	52	43	0	207	226[b],219[e]
SWNC	Swannanoa School	C	2156	353	93	22	350	546[d]
TPLC	Templeton School	C	1235	227	93	43	283	398[d]
MGCS	Blenheim Marlborough Girls College	M	1123	158	92	48	303	375[h]
LHUS	Lower Hutt Unilever	W	272	35	33	5	242	212[e]
PIPS	Aotea Quay Pipitea	W	146	49	37	0	326	210[f]
TFSS	Wellington Thorndon Fire Station	W	562	168	67	22	298	274[e],245[f]
VUWS	Victoria University Law School	W	249	219	68	10	312	286[f]
WEMS	Wellington Emergency Management Office	W	535	136	50	15	257	265[e],245[f]

3.4 Ray parameter estimation

The ray parameter p is one of the parameters required to estimate V_S and V_{S30}. It can be estimated using Equation 3.2 for records with known hypocentral location, and if enough is known about the subsurface velocity structure to identify a major refraction boundary between the source and site. This occurs at the location of the largest impedance contrast, the basement, the depth of which can be measured or estimated by various approaches but herein is obtained from regional basin models that have been developed for the New Zealand Velocity Model (NZVM) (Deschenes et al., 2018; Thomson et al., 2020). Both simplified one-dimensional "layer cake" and two-dimensional approaches were implemented. The need for a strong velocity contrast imposes a limitation on the sites at which the P-wave method can be applied. The NZVM represents V_S with simple smoothly-increasing functions depth wherever velocity contrasts have not been specifically identified (whether by geophysical methods such as seismic tomography, or by inferential extrapolation of rock elevation from nearby slopes, as in sedimentary basins). So sites where the NZVM does not identify a strong velocity contrast are not amenable to the P-wave method.

3.4.1 One-dimensional profiles

One-dimensional (1-D) profiles for each site were obtained by querying New Zealand basin P-wave velocity models directly beneath each seismic station and taking the impedance contrast as the midpoint between the two points with the maximum P-wave velocity contrast (measured as the difference of the log of adjacent V_P values). This point typically corresponds to a rock surface and is identified as the basement (Figure 3.3). 1-D NZVM queries return a vector of P-wave velocities increasing with depth at a specified resolution (chosen as 100 metres). Representative P-wave velocities were assigned each of the two layers by time-averaging V_P along the profile from the ground surface to the basement, and from the basement to the hypocentral depth. The ray parameter p was estimated by finding the refraction point corresponding to minimum travel time for a P-wave traveling through the two-layer domain from source to site. This can be found as

$$p = \frac{\sin\left(\tan^{-1}\left(\frac{R_1}{D_1}\right)\right)}{V_{P1}} = \frac{\sin\left(\tan^{-1}\left(\frac{R_2}{D_2}\right)\right)}{V_{P2}} \tag{3.5}$$

where R_1 and R_2 refer to the horizontal components of straight-line distance travel for the ray paths in the upper and lower layers, respectively; D_1 and D_2 refer to the corresponding vertical distance components; and V_{P1} and V_{P2} are the P-wave velocities in the upper and lower layers. These variables are presented schematically in Figure 3.3. Also shown in the figure are the incident and refracted angles for the upgoing ray, i_2 and i_1 respectively. These angles are the same as those for reflection at the ground surface (Figure 3.1) and for Snell's law and the definition of the ray parameter p (Equation 3.2).

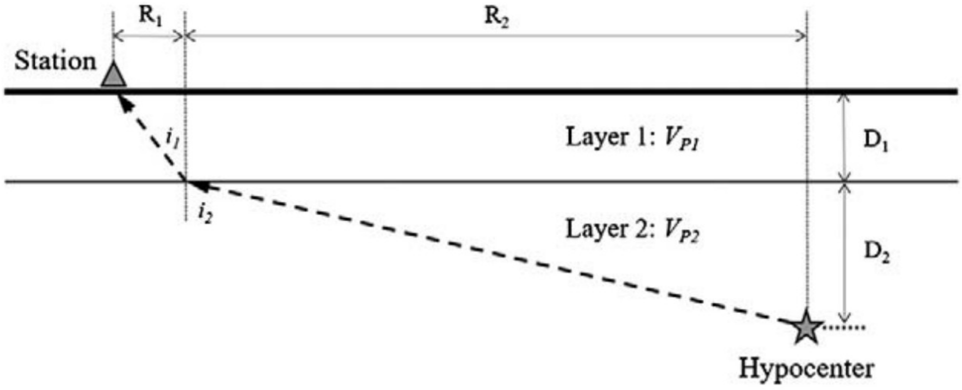


Figure 3.3: Schematic of P-wave traveling through a simplified one-dimensional velocity model characterized by two layers. The ray parameter is estimated by finding the point of refraction corresponding to the minimum travel time from source to site. From Zalachoris et al. (2017).

Since the coordinates of the strong-motion station are used for querying the velocity model, the one-dimensional velocity layer cake model is computationally expedient in that the velocity model needs only be queried once for each site (as opposed to once for each strong-motion recording). Since waves tend to refract to near-vertical angles for the typically significant velocity contrasts at the basement, sampling the velocity model directly beneath the site (as opposed to some location between the site and epicenter for each event) is judged to be a reasonable simplification. The two-dimensional alternative, discussed below, offers an opportunity for quantitative evaluation of this tradeoff between accuracy and expediency.

3.4.2 Two-dimensional profiles

The two-dimensional (2-D) approach to estimating p is conceptually similar to the one-dimensional method. It still assumes a single point of refraction, but the basement depth is obtained by querying a "slice" (transect) of the three-dimensional velocity model between the recording station and hypocenter for every ground motion record. Thus the 2-D method reasonably assumes a constant ray azimuth (*i.e.*, the travel path of the first P-wave appears as a straight line in plan view), and the basement depth varies as a function of horizontal distance. An example profile is shown in Figure 3.4.

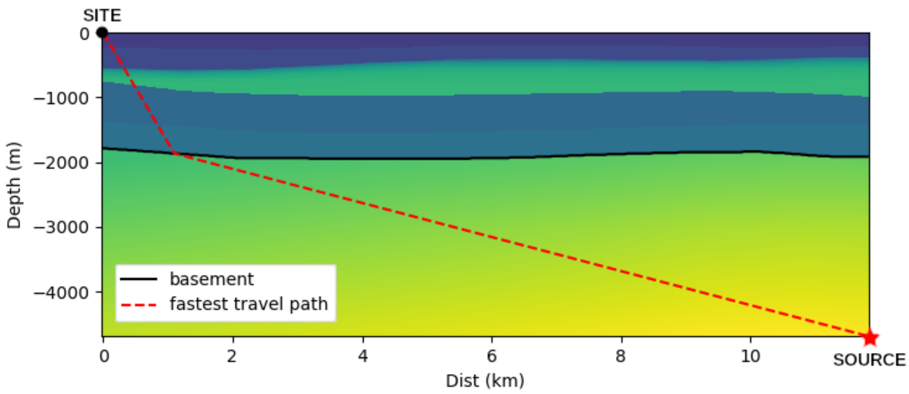


Figure 3.4: Schematic of P-wave traveling through a two-dimensional "slice" of the basin velocity model.

The ray parameter p is estimated by searching along the basement surface (represented as a heavy black line in Figure 3.4) and computing a travel time for every hypothetical refraction point as the sum of the two straight-line travel paths (represented as a dashed line in the figure). P-wave velocity was sampled uniformly from the NZVM along the travel path so that the travel times were as close as possible to reality as represented by the NZVM.

The vast majority of slices are closer to the idealized one-dimensional "layer cake" assumptions than the example in Figure 3.4 suggests. This particular example is chosen to highlight a couple of considerations that arise for the two-dimensional case. First, since the basement surface is in general nearly horizontal, any deviation from horizontal at the point of refraction is ignored when computing angles i_1 and i_2. Second, there is a shear wave velocity reversal (geology wherein V_S is not monotonically increasing with depth) underlying some parts of Christchurch, owing to the Banks Peninsula Volcanics formation. Velocity reversals introduce a nonuniqueness property to wave path calculations, and there is no straightforward way to address this in the context of this study. Where shear wave reversals are present in the profile, our approach was to ignore them and take the deepest significant velocity contrast in the profile as the basement surface.

3.5 Obtaining ratios

The ratio of the radial component of velocity to the vertical component ($\frac{\dot{U}_R}{\dot{U}_Z}$), a special case of the horizontal-to-vertical (H/V) ratio (Nakamura, 1989), is the other parameter required to estimate V_S and V_{S30} (Equation 3.4). It is taken instantaneously at the peak in the vertical trace $\dot{U}_Z(t)$ for the first P-wave arrival, t_{peak}, assuming that the earliest part of the ground motion record represents pure P-wave motion without the interference of other wave types (Kim et al., 2016). The vertical and radial components of velocity are generally in phase or nearly so, so that the ratio is positive and stable in the vicinity of the first peak. In a subsequent section (Section 3.8.2), exceptions to this are discussed. Since negative ratios are not consistent with the other simplified/idealised assumptions of the P-wave method, any negative values of $\frac{\dot{U}_R}{\dot{U}_Z}$ are discarded and not used to generate V_{S30} estimates. For simplicity, hereafter the quantity $\frac{\dot{U}_R}{\dot{U}_Z}$ is sometimes referred to simply as the "ratio."

Because the P-wave method relies on velocity (rather than acceleration), baseline error is a pernicious problem for applying the method to records processed in an automated or semiautomated fashion. Even with best practices for filtering and baseline adjustment, some degree of drift (cumulative error arising with time-integration) is unavoidable. Some pre-event noise must be left at the beginning of the record to allow for padding (Boore, 2005; Boore and Bommer, 2005). Furthermore, many phase-picking algorithms (including Akazawa, 2004, used herein), rely on some local averaging; consequently it is not a trivial problem to use automated methods to trim pre-event noise so precisely as to completely eliminate baseline error. To address baseline drift, this work uses automated and manual variants of the secondary, local baseline correction (LBC) proposed by Kang et al. (2020). The latter is used to validate the former; these are discussed in turn below.

3.5.1 Manual picks

An interactive program with graphical user interface (GUI) (Figure 3.5) was developed to allow rapid manual picking of first pulse arrivals and associated $\frac{\dot{U}_R}{\dot{U}_Z}$ ratios. The program integrates accelerograms to obtain velocity and shows the radial and vertical components of velocity on one axis, with the continuous ratio $\frac{\dot{U}_R}{\dot{U}_Z}$ below it. The user can apply "manual" LBC by adjusting the four independent parameters (two parameters each for linear correction functions on the vertical and radial velocity traces), then click to select the moment of the first vertical velocity peak and save it to a datafile. The user can also assign a binary "keep" flag to allow rejection of any record of such poor quality that the first P-wave pulse cannot be identified. After the initial SNR-based culling, however, these records were so few as to be statistically insignificant. Theoretical arrival time t_{TAT} and the automated P-phase arrival time t_{pick} are marked in the GUI for reference; this allows the user to better assess potentially erroneous automated picks, false triggers, *etc.* A similar approach was followed by Hosseini et al. (2016) in their manual data processing. Other pertinent metadata such as epicentral distance and event magnitude are also shown for each record.

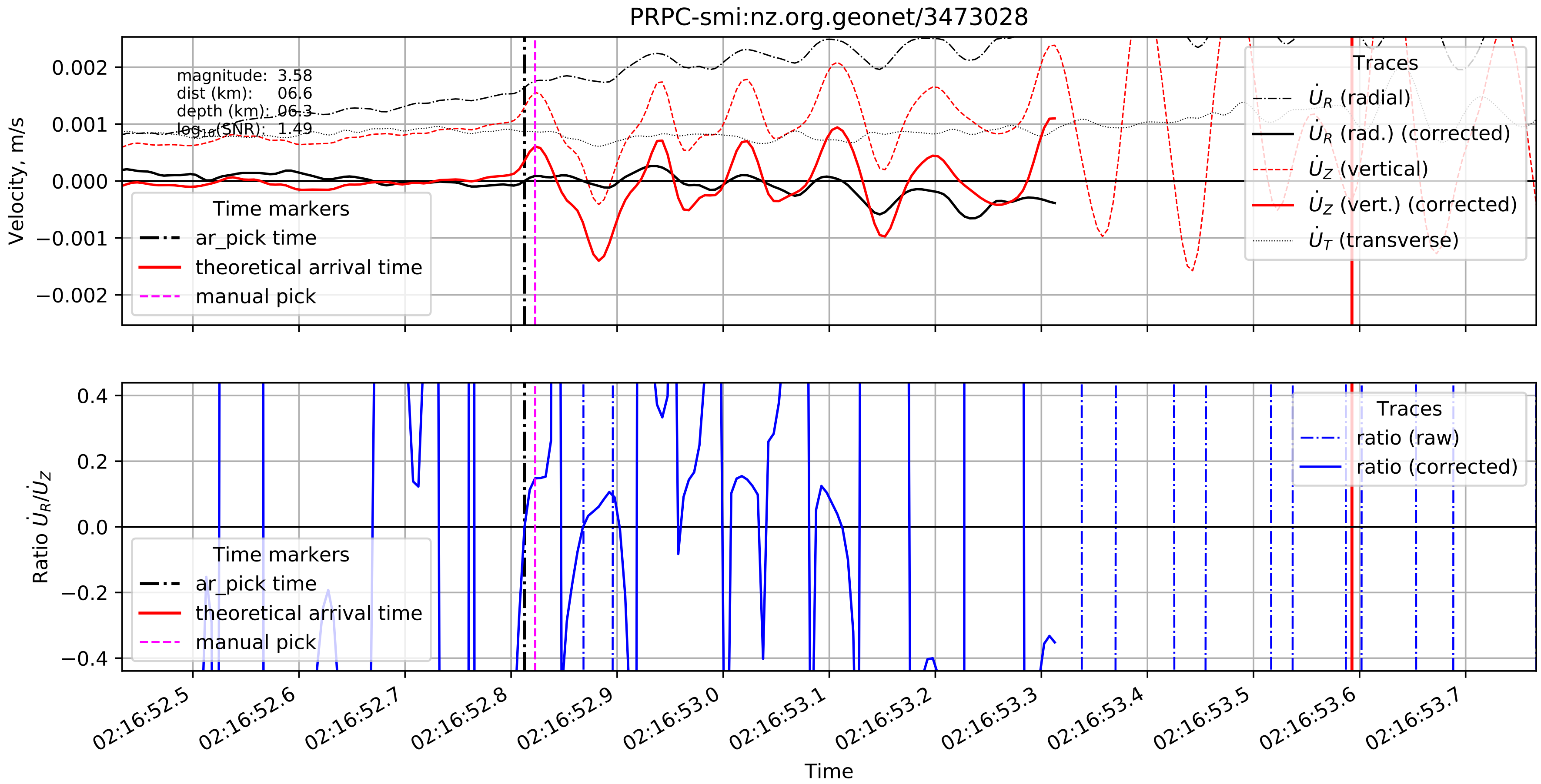


Figure 3.5: User-pick program. Vertical and radial components of velocity (upper pane, red dashed and black dash-dotted traces respectively) are manually corrected with a linear function to reduce the influence of long-period noise and/or baseline drift. The corrected vertical and radial components appear as heavy red and black lines in the upper pane. (The transverse component is shown, but not used). In the bottom pane, continuous ratio $\frac{\dot{U}_R}{\dot{U}_Z}$ is plotted for the raw and corrected traces as dash-dotted and heavy solid lines, respectively. The manual user pick for the first arriving vertical pulse, t_{peak}, is shown in both panes as a heavy magenta dashed line. Theoretical arrival time and the `ar_pick` arrival time t_{pick} are shown as red solid and blask dash-dotted vertical lines, respectively.

The approach chosen for manual pulse picking and LBC is time-consuming. It was impractical to perform this process on all (nearly 12,000) ground motion recordings, so a random subset was used instead. The subset of ground motion recordings chosen for manual pulse picking needed to balance two considerations: (1) finding the very best possible estimates of V_{S30} for each station within the limitations of the P-wave method, and (2) validating the automated LBC procedure (below). In light of this, a subsetting scheme was selected whereby for each station, the 20 highest-SNR ground motion records were retained, as well as a sampling of records across a range of SNR—a maximum of 20 each within six logarithmically-spaced SNR bins. This yielded a total of 3,221 records with good representation across both SNR and unique seismic stations. The number of manually-processed ground motion records for each station is reported as N_{manual} in Table 3.1.

3.5.2 Automated picks

To find the peak of the first vertical velocity pulse automatically, the first zero-crossing in the vertical acceleration record after the P-phase arrival (using the automatically-chosen phase arrival time t_{pick}) is used.

For obtaining useful values of the vertical and radial velocity components, LBC must be used to account for baseline drift. Kang et al. (2020) implemented LBC as follows: For each component (radial and vertical), the velocity average over a time window of length Δt_{LBC} preceding t_{pick} was subtracted from each velocity trace to counteract any cumulative drift resulting from the integration of pre-event noise. This study follows Kang et al. (2020) in using $\Delta t_{\text{LBC}} = 0.5$, but we apply a linear function of time (rather than a constant) correction which yields a slightly more accurate t_{peak} than the constant variant. This conclusion was based upon comparison with manual LBC (next section).

3.6 Results

In subsequent sections results are discussed for V_{S30} estimation by various methods (one-dimensional and two-dimensional velocity models; manual and automated pulse picking).

3.6.1 1-D results

A summary of V_{S30} data for each site and the corresponding estimates derived from the P-wave method is presented in Figure 3.6. Individual estimates from the P-wave method (one estimate per recording) are shown as dots, with those derived from auto-picked ratios shown on the left side of each station as blue dots, and manually-picked ratios (fewer in number) shown on the right side as orange dots. (Only a subset of the motions were picked manually as discussed in Section 3.5.1). The translucent overlays for each site show individual V_{S30} measurements and a composite distribution derived from all available single V_{S30} measurements as red (left) and purple (right) boxes, respectively. Each box is vertically symmetrical; the centerline shows the best-estimate V_{S30} and the top and bottom indicate reported measurement uncertainty as ± 1 standard deviation (σ). For sources with no reported standard deviation, $\sigma = 0.1$ was assumed (Moss, 2008). The red (left-side) individual V_{S30} values in Figure 3.6 come from Table 3.1. Wherever only one measurement is available for a site (*e.g.* CRLZ), the individual and composite distributions are identical. Finally, for comparing the P-wave method results against a proxy-based method, model estimates from the worldwide slope-based V_{S30} model by Allen and Wald (2007) are shown as red squares.

It is clear that some sites exhibit systematic, often significant, prediction bias. In a subsequent section we examine the question of site-specific bias, and whether any correlations with other factors (geology, regional effects *etc.*) can be found that might elucidate the utility of the P-wave method at particular sites.

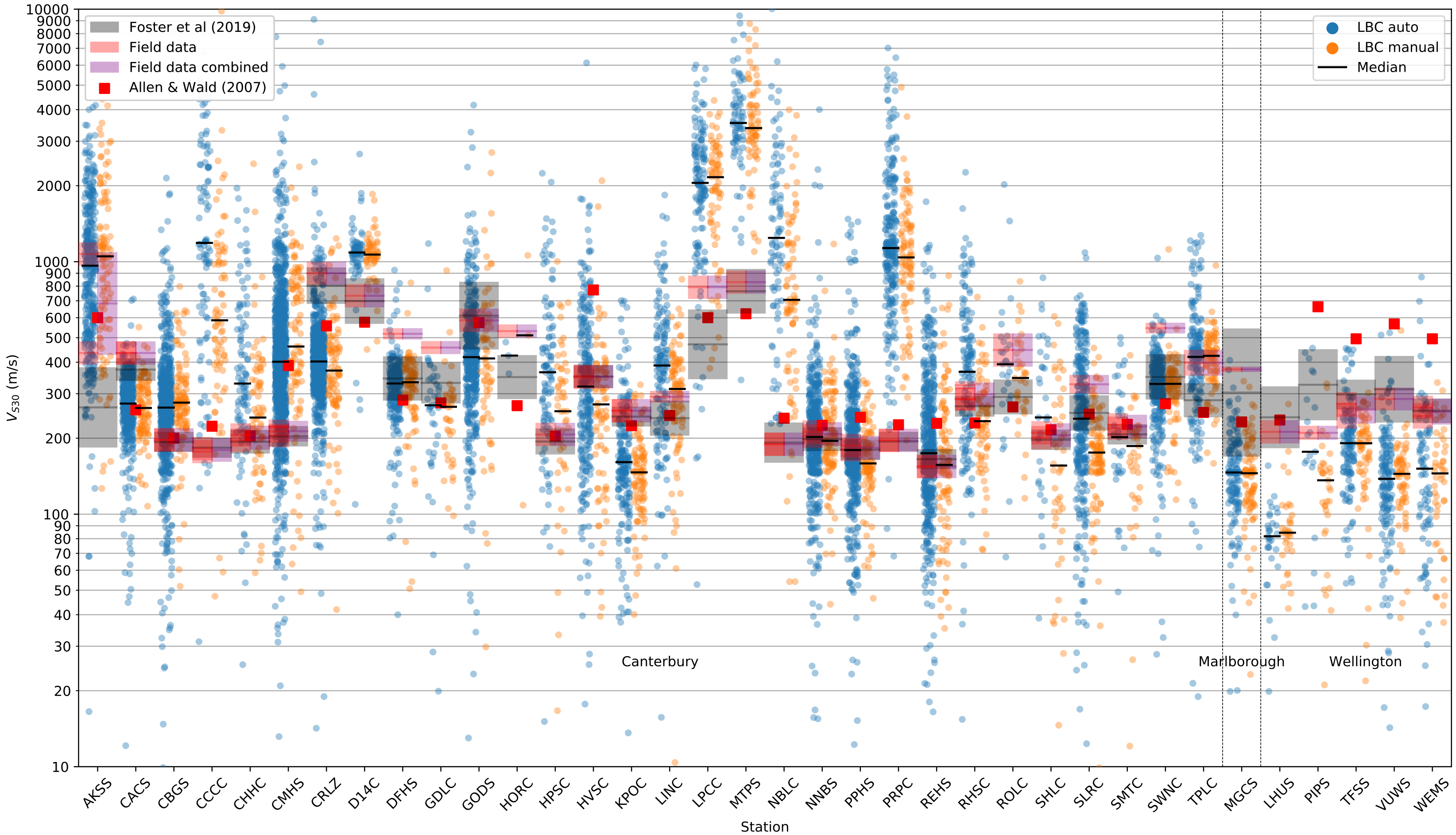


Figure 3.6: V_{S30} estimates for the 1-D case (Section 3.6.1) plotted by station for ground motion recordings with $\frac{\dot{U}_R}{\dot{U}_Z}$ determined automatically (left, blue dots) and manually (right, orange dots). Medians for each method are marked by horizontal black lines. Colored V_{S30} measurements for various data sources are shown as overlay rectangles, with uncertainty for each source represented as $\pm\sigma$. Left-hand (red) rectangles represent individual data sources as shown in Table 3.1 and right-hand (purple) rectangles show composite distributions for all available measurements. Similarly, Foster et al. (2019) distributions (Chapter 2) are also shown as gray overlay rectangles spanning the full width of each station. V_{S30} estimates obtained from the worldwide slope-based model by Allen and Wald (2007) are shown as red squares. Station ordering is by region (Canterbury, Marlborough, Wellington) and then alphabetically. The five Wellington stations all show underprediction of V_{S30}.

Figure 3.7a shows the accuracy of V_{S30} estimates based on manual selection of $\frac{\dot{U}_R}{\dot{U}_Z}$ as a function of $\log_{10}$(SNR) for the set of ground motions that were examined manually. The vertical axis shows residual (natural log of the ratio of observations to predictions, $\ln \frac{\text{obs.}}{\text{pred.}}$) for the V_{S30} estimates derived from the manual $\frac{\dot{U}_R}{\dot{U}_Z}$ picks, for all sites where measurements of V_{S30} were available. Boxplot overlays and the red, black and blue lines represent the quartiles, mean, median and standard deviation of the residuals binned by SNR. These provide a sense of the correlations between SNR and the precision and bias of the V_{S30} predictions for the 1-D case. The mean and median residuals are fairly close to zero for all bins (except for the erratic trends at very high SNR because of sparse data). There is a slightly higher likelihood of drastic overprediction than underprediction, which is likely the reason for the mean (red line) trend being consistently slightly lower than the median (black line). There is obviously there is no practical benefit to using SNR-based retention criteria with manually-picked $\frac{\dot{U}_R}{\dot{U}_Z}$ pulses (manually-processed records are retained or rejected on the basis of judgment for each individual ground motion recording), but a direct comparison with the automatically-processed case is useful.

Figure 3.7b shows the same relationship for V_{S30} estimates based upon automated processing (Section 3.5.2). The automated processing introduces a systematic bias to estimates for records with $\log_{10}$(SNR) less than about 1.6. However, Figure 3.2 and Table 3.1 show that imposing a cutoff of $\log_{10}(\text{SNR}) \geq 1.6$ would reduce the number of useable recordings significantly, so is not an ideal solution to the problem of bias in noisy records. Kang et al. (2020) also found a nontrivial bias for noisy records, with the residuals also negative in sign, indicating model overprediction.

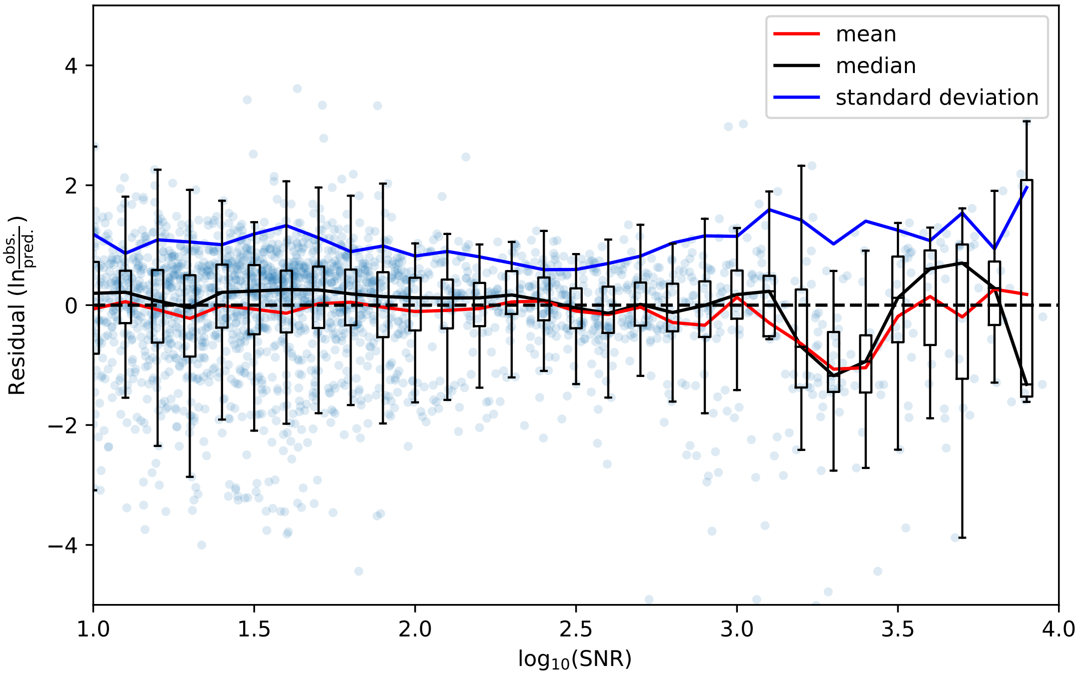
Figure 3.7 shows that there is a decidedly stronger tendency toward overprediction at low SNR for automated approaches than manual. This overprediction is in part an emergent feature of some arbitrary but systematically faulty behaviours in the automated approach, which are eliminated or partially corrected through the application of superior human pattern-recognition in the manual approach.

Some typical cases include a nonlinear trend in the 0.5 seconds prior to P-phase arrival, and any records where the `ar_pick` algorithm produces inaccurate phase picks. On the other hand, the main tradeoff in the automated approach for a large number of records is more scatter in predictions (lower precision), with a relatively modest increase in model bias for low SNR. An obvious conclusion from Figures 3.6 and 3.7 is that the automated method gives predictions that are reasonably close to manual picks, so long as there are a large number of mostly good-quality ground motion recordings from which to generate estimates.

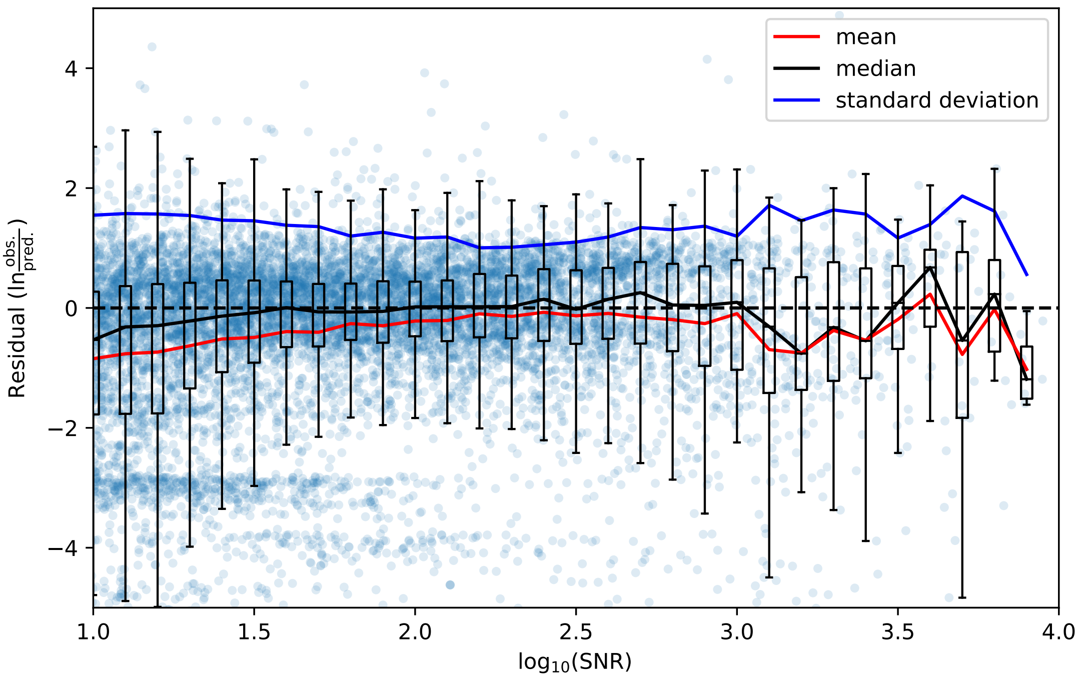
3.6.2 Improvements related to 2D profiles

The residuals for the 2-D variation are presented for the manually-processed and automatically-processed data in Figure 3.8 and can be compared directly to Figure 3.7. Residuals are also shown on a per-station basis in Figure 3.9 for the 1D and 2D cases (blue and orange dots, left and right, respectively), using V_{S30} derived from manually-picked ratios. The residuals shown in Figure 3.9 are thus the same as shown in Figures 3.7a and 3.8a. Similarly to Figure 3.6, red squares in Figure 3.9 show the residuals corresponding to slope-based V_{S30} estimates obtained from the global model by Allen and Wald (2007). These are shown to facilitate comparison between the P-wave method and a widely-used proxy-based model.[4]

[4]Foster et al. (2019) (Chapter 2) was not chosen for this purpose because it was calibrated in New Zealand using some of the same V_{S30} measurements used here for validating the P-wave method, as well as being spatially conditioned using geostatistics, so the comparison would be too self-referential to be useful.

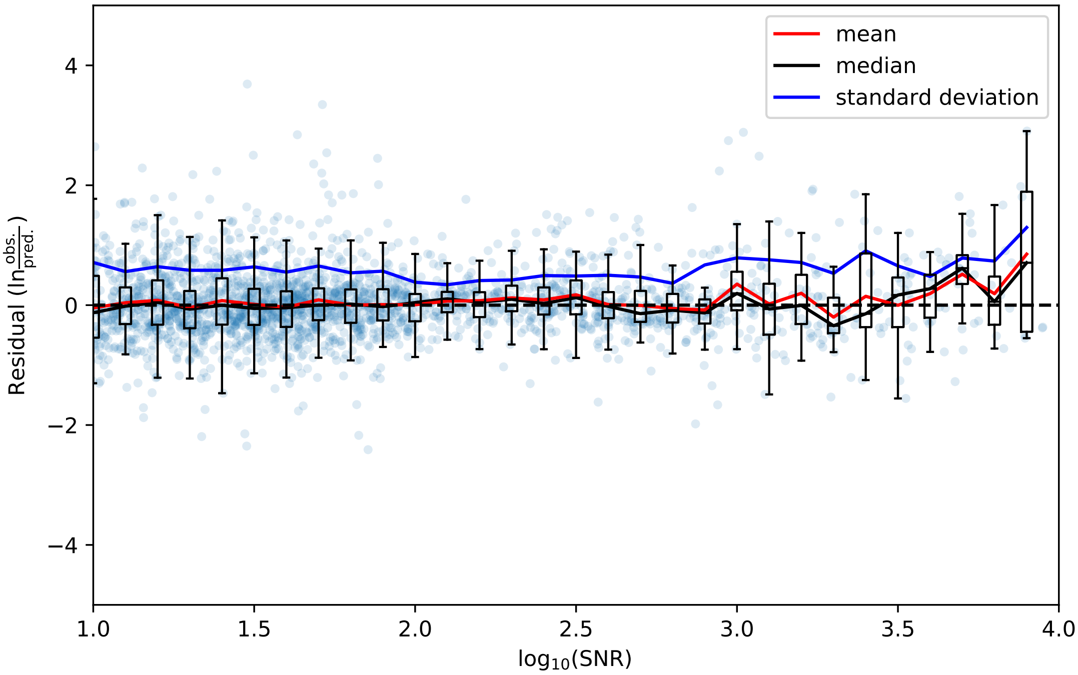


(a) For recordings with estimates based on manual peak and ratio picks.

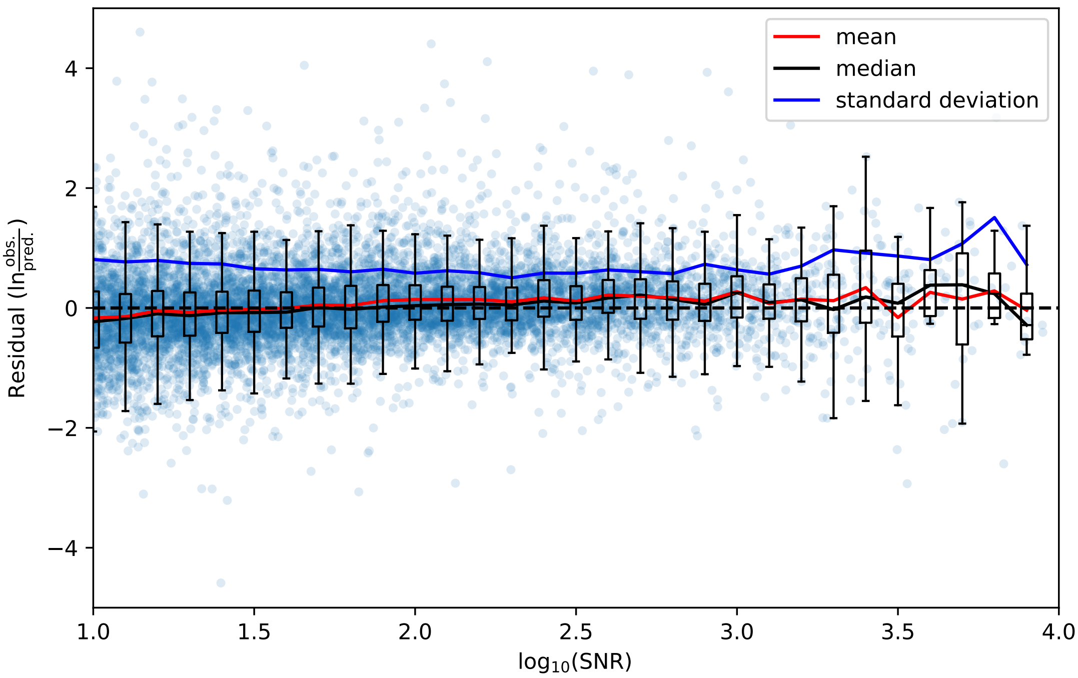


(b) For recordings with estimates based on automated peak and ratio picks.

Figure 3.7: Residuals of V_{S30} ($\ln \frac{\text{obs.}}{\text{pred.}}$) plotted against signal-to-noise ratio (SNR) for the 1-D approach (Section 3.6.1). Boxplots show distributions of residuals binned by SNR. Red, black and blue lines show mean, median and standard deviation respectively for each bin.



(a) Same as Figure 3.7a, but using the 2-D approach.



(b) Same as Figure 3.7b, but using the 2-D approach.

Figure 3.8: Residuals of V_{S30} ($\ln \frac{\text{obs.}}{\text{pred.}}$) plotted against signal-to-noise ratio (SNR) for the 2-D approach (Section 3.6.2). Boxplots show distributions of residuals binned by SNR. Red, black and blue lines show mean, median and standard deviation respectively for each bin.

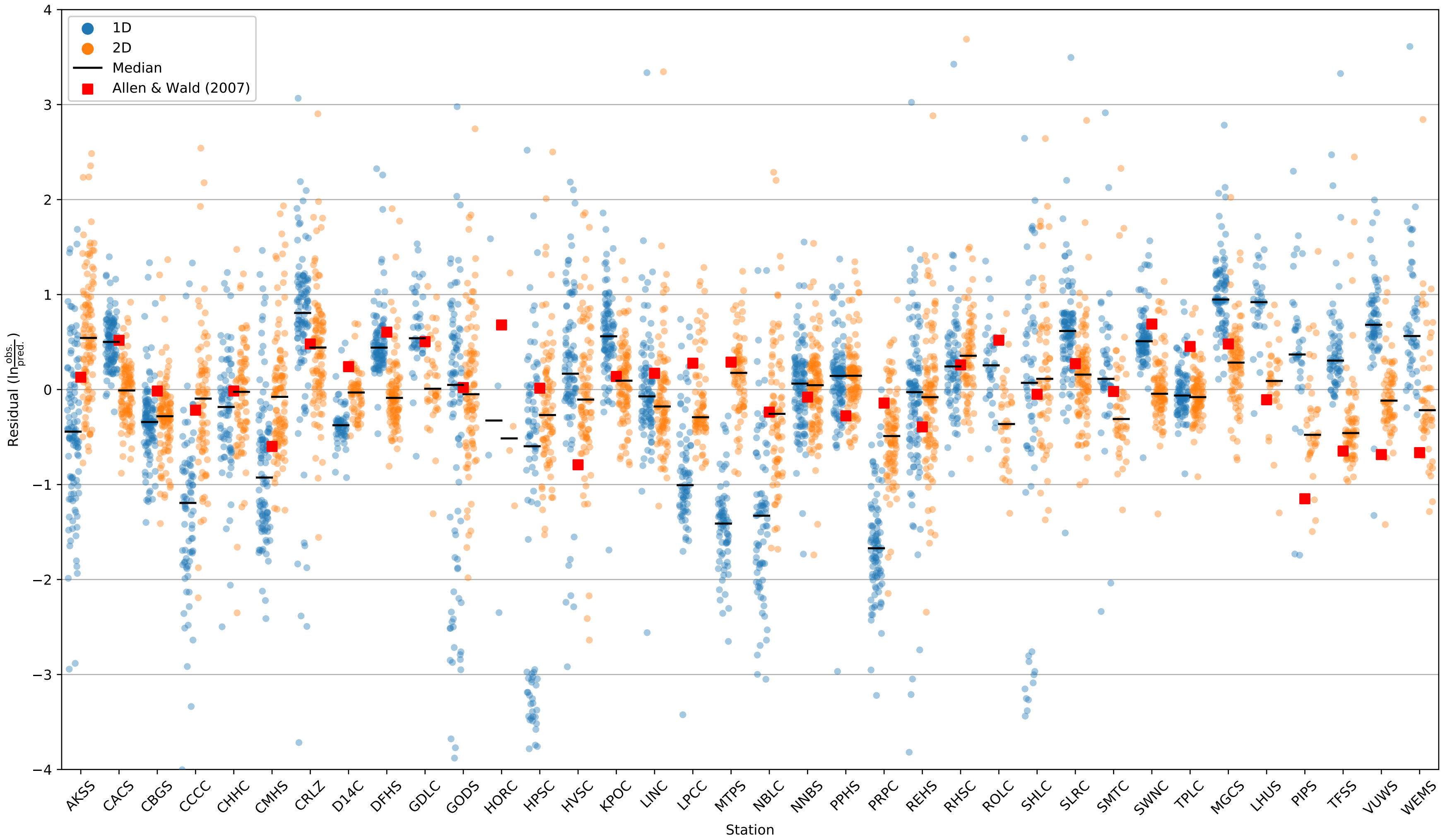


Figure 3.9: V_{S30} residuals plotted by station for the subset of ground motions recordings with $\frac{\dot{U}_R}{\dot{U}_Z}$ determined manually. The residuals for the 1D and 2D case are shown as blue (left) and orange (right) dots, respectively. The binwise median values are shown as heavy black lines. For comparison, the global slope-based V_{S30} model estimates from Allen and Wald (2007) are shown as red squares. Station ordering is by region (Canterbury, Marlborough, Wellington) and then alphabetically.

It is clear from comparing Figure 3.7a to 3.8a and 3.7b to 3.8b, as well as from Figure 3.9, that the 2-D approach yields an improvement in V_{S30} estimates irrespective of other details. This can be appreciated in Figure 3.10, where the probability density functions of the median per-station 1- and 2-D P-wave model residuals (black lines from Figure 3.9) and the Allen and Wald (2007) slope-based model residuals (red squares from Figure 3.9) are estimated using a Gaussian smoothing kernel with a width of 0.5. The figure suggests that for the 36 validation stations considered in this study, the 1-D P-wave method performs approximately as well as the proxy (slope-based) method, with a comparable variance and roughly zero bias, while the 2-D P-wave method exhibits a lower variance in residuals, indicating that it outperforms the proxy-based approach by a modest but nontrivial margin in terms of precision. The median and standard deviation for the residuals underlying the density estimates in Figure 3.10 are presented in Table 3.2. Here it can be seen that the standard deviation for the 1-D residuals is significantly higher than for the Allen and Wald (2007) model; this may be in part due to the "banding" of negative-valued residuals discussed presently.

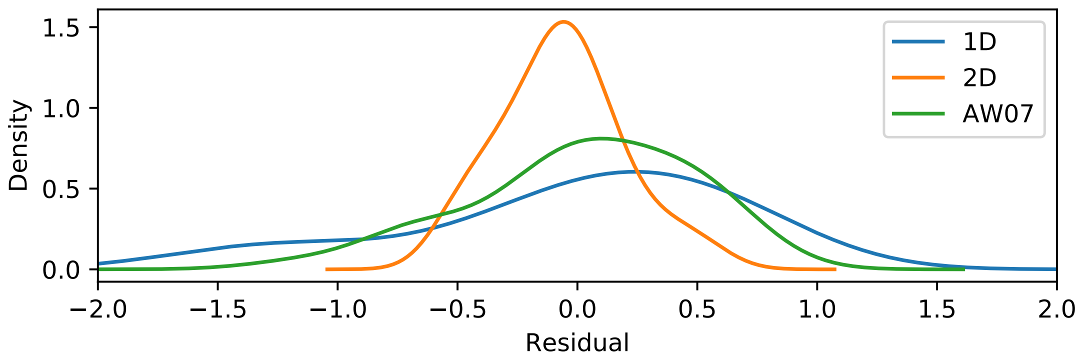


Figure 3.10: Kernel density estimates for the distributions of the median model residuals for each station for the 1-D P-wave method (blue), the 2-D variation (orange), and for the Allen and Wald (2007) slope-based proxy model (green). These distributions are summaries of the information shown in Figure 3.9. The 1-D P-wave method performs with roughly similar accuracy and precision as the Allen and Wald (2007) model, while the 2-D variation of the P-wave method outperforms the proxy model. Smoothing is from a Gaussian kernel with window width of 0.5. The statistics for the residuals are presented in Table 3.2.

With respect to the tradeoffs between manual and automated pulse/ratio

Table 3.2: Median and standard deviation for the collection of per-station residuals used to generate Figure 3.10.

	1D	2D	AW07
Median	0.092	-0.078	0.018
Std. Dev.	0.668	0.250	0.447

picks, there is a modest improvement of both bias and precision for the manually-processed subset compared to the automated for the 2-D approach as well. (Figure 3.8) However, the improvement is much more modest in the 2-D approach than for the 1-D: the precision improves on the order of about 0.1 standard deviation, while the bias (as represented by the mean or median of the residuals) goes from about -0.1 to zero for low-SNR records, and from about 0.1 to zero for higher-SNR records. From Figures 3.7 and 3.8 it can thus be inferred that manual processing of motions (instead of automated processing) confers a relatively small advantage compared to the 2-D representation of the problem (instead of 1-D).

One feature of the residuals from the automated 1-D case (Figure 3.7) is the apparent clustering of many residuals in "bands," most visible in the negative residuals near the lower-left of Figure 3.7b. This clustering can be understood as an artifact of the decision to generate the 1-D subsurface model (required to determine the ray parameter) from the basement depth at the location of the recording site. In the 1-D approach, it is assumed that all records at a given site have the same basement depth (and hence same refraction depth). In reality, each recording is of course associated with a unique rupture, hypocentre, azimuth and refraction depth. Since this is not captured by the simplified assumptions of the 1-D approach, a salient difference between the 1-D and 2-D approaches can be thought of as the loss of a degree of freedom in the parameterisation of the problem geometry. This does not capture the differences between the approaches completely, but since the NZVM—like the earth it represents—has far more homogeneity laterally than vertically, and since neither the NZVM nor the P-wave method is able to account for certain other real-world complexities such as topographic differences, the more faithful representation of basement depths for events originating at different azimuths is the most significant element of the observed improvement of the 2-D approach over the 1-D approach.

Figure 3.11 shows the same information as Figure 3.8b but the boxplot and line overlays for each SNR bin show the statistics for *all* residuals with SNR greater than equal to the SNR. (Statistics are shown for a minimum threshold SNR rejection, rather than "binwise" statistics). This view on the data is useful for evaluating the "quantity/quality" tradeoff that arises when using weak ground motion data and was summarised briefly above with respect to the difference between automatic and manual picking (Section 3.6.1; Figure 3.7). As expected, in Figure 3.11 the statistics change more smoothly with increasing SNR than in Figures 3.7 and 3.8. Figure 3.11 also shows that good-quality records tend to compensate for any poor predictions associated with noisy records, and it is not necessarily unreasonable to retain noisy records in estimating V_{S30}.

3.7 Correcting for takeoff angle

Kang et al. (2020) investigated the correlation of takeoff angle with V_{S30} residuals. Takeoff angle is the initial angle of the ray representing the first P-wave arrival measured from vertical (i_2 in Figure 3.3). Kang et al. (2020) determined that there is a systematic bias in V_{S30} predictions at low (near-vertical) takeoff angles, which can also be understood as events with short horizontal distance from the recording site.

The correlation between takeoff angle and V_{S30} prediction residuals is examined here for the 2-D results, following Kang et al. (2020). The data are unbalanced with respect to recording site (*i.e.*, some sites have many recordings and some have few). Consequently, any proposed bias correction needs to accommodate this or else the correction will reflect the highly local and study-specific balance of data under inspection. (*i.e.*, bias will be dominated by sites with many recordings).

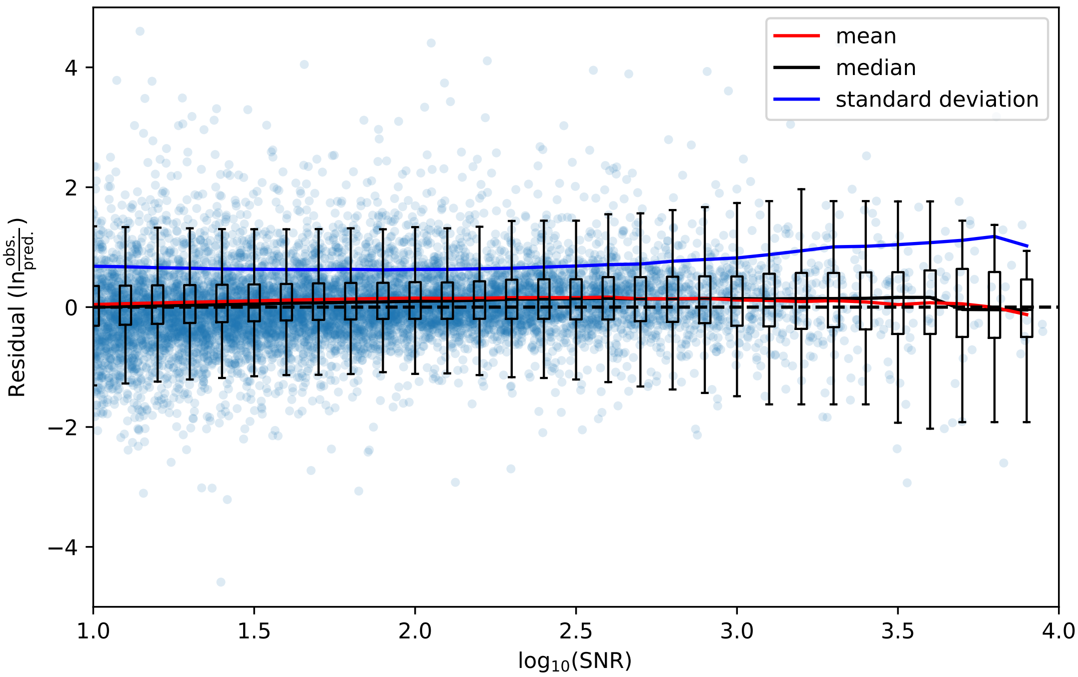


Figure 3.11: Residuals of V_{S30} ($\ln \frac{\text{obs.}}{\text{pred.}}$) plotted against signal-to-noise ratio (SNR) for the 2-D approach (Section 3.6.2). Each boxplot summarises the distribution of residuals greater than or equal to a given value of SNR. In other words the residuals shown are the same as in Figure 3.8b, but the boxplots represent statistics for a "threshold" collection of residuals rather than the "binwise" statistics shown in Figures 3.7 and 3.8. The red, black and blue lines show mean, median and standard deviation respectively for each boxplot.

Accordingly, the residuals are partitioned into "within-site" and "between-site" residuals so as to reduce or eliminate the problem of "unbalanced" data. This is known as random-effects modelling and entails optimizing the two components of each residual so as to maximize the likelihood that both within- and between-site residuals are normally distributed. Partitioning can be implemented following Abrahamson and Youngs (1992), or applied using the `lme4` package for the R statistical programming language (Bates et al., 2014).

Figure 3.12 shows the within-site residuals plotted against takeoff angle, with binned statistics shown as in previous figures and a fitted curve,

$$y = -2.2e^{-\frac{x}{7.6^{\circ}}} \tag{3.6}$$

plotted as a green dash-dotted line. These results are in good visual agreement to those shown by Kang et al. (2020); however, there is a discrepancy between the plotted results and reported curve fit in that work (*i.e.*, the reported equation does not correspond to the plotted curve).

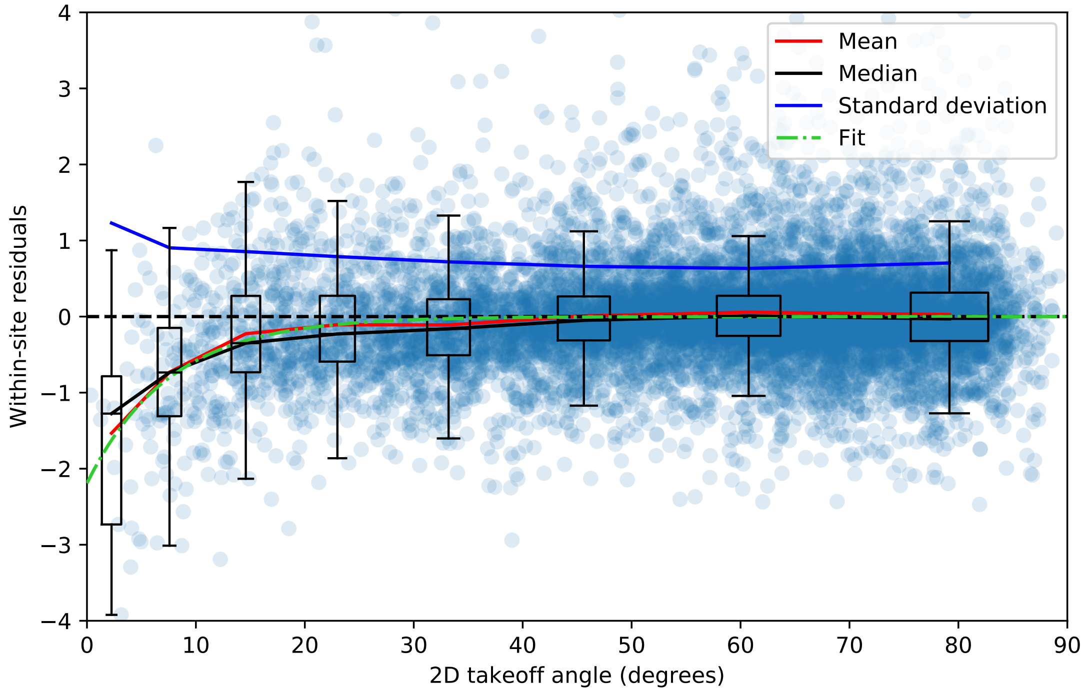


Figure 3.12: Within-site residuals plotted against takeoff angle; binned statistics shown similar to Figures 3.7-3.11.

P-wave model predictions of V_{S30} can be adjusted using the relationship in Equation 3.6. The relatively small number of low-takeoff-angle records means that overall statistical performance is essentially unaffected. When applying the P-wave method for forward prediction, however, the above takeoff angle correction is a prudent measure for sites with few recordings, and is corroborated by both our work and Kang et al. (2020).

3.8 Site-specific performance indicators

Figure 3.6 shows that some strong motion stations give consistently better V_{S30} predictions than others. A question worth pursuing is whether any readily-available information can give insight into the predictive performance of the P-wave method for a particular site. The guiding assumption is that wherever geologic conditions can be closely approximated by the simplified representation of Figure 3.3, the P-wave method will perform well; wherever there are significant departures from these idealised assumptions (*e.g.*: non-flat surface topography, multiple distinct geologic layers above the hypocentre, shear wave velocity reversals), the P-wave method will perform poorly. In the subsequent discussion, references to "idealised" conditions will refer to the assumptions shown in Figure 3.3: flat ground, two distinct geologic layers separated by a flat basement surface, constant elastic moduli within each layer, $V_P > V_S$ in both layers (always true for geomaterials), and $V_{P1} < V_{P2}$ (usually true)[5]. Two promising avenues for this investigation are statistics derived from a digital elevation model (DEM), and the prevalence of negative $\frac{\dot{U}_R}{\dot{U}_Z}$ ratios. These are discussed in turn.

[5]The most common exceptions—where $V_{P1} > V_{P2}$—are in volcanic areas, where one or more dense lava flows occured atop a soil layer or less-dense rock layer. This is typically associated with multiple major refraction boundaries in the near-surface, above the seismogenic zone, and hence these cases are associated with several major departures from idealised assumptions. The Banks Peninsula Volcanics in Canterbury (Figure 3.4) are an example.

3.8.1 Topographic slope

Topographic slope is a good statistic to investigate for insight into the applicability of the P-wave method, since the method is based upon the assumption of a uniform and horizontal layering structure and ground surface, and real-world departures from the flat-ground model are often (not to say always) associated with non-zero topographic slope.

Foster et al. (2019) (Chapter 2) generated DEM statistics (slope, convexity, and a texture metric) and from these generated maps for the "terrain" categories by Iwahashi and Pike (2007) for New Zealand (Section 2.4.2). Both slope and the Iwahashi and Pike categories were generated from a raster representation of the DEM sampled at 100-metre spacing. In areas where there are sharp changes in terrain (*e.g.* terraced river valleys, or at the toe of steep mountains), slope and other DEM-based statistics can be expected to change rapidly, with aliasing effects impacting the DEM statistic associated with each site. Additionally, the scale at which the DEM is sampled may not be inconsequential in its suitability as a proxy for the efficacy of the P-wave method. In other words, most hypocentral depths are on the order of a few kilometres and most source-to-site distances are on the order of a few kilometres or tens of kilometers, rather than a few hundreds of metres; consequently, it is possible that any trend between slope and V_{S30} residual may be more apparent for slopes measured on (say) a 1km grid than a 100m grid. To account for this possibility, DEM statistics were re-generated at 200, 500, 1000, and 2000m grid spacings in addition to the 100m versions used by Foster et al. (2019).

The residuals from Figures 3.8b and 3.11 are averaged for each site and plotted against slope in Figure 3.13, with all five grid spacings plotted on the same axes (so five points for each site are shown). While the variation in each site's slope for the five grid spacings is essentially random, an apparent (very weak or perhaps coincidental) overall positive correlation is evident, indicating a tendency for overprediction at flat sites and underprediction at steeper sites. The same weak correlation is visible in Figure 3.14 where residuals are plotted against the sixteen discrete Iwahashi and Pike (2007) categories, which are generated using slope as a first-order discriminator. (The trend appears reversed in Figure 3.14, but this is because the categories are defined with lower-numbered categories having steeper slopes and higher-numbered categories having flatter slopes).

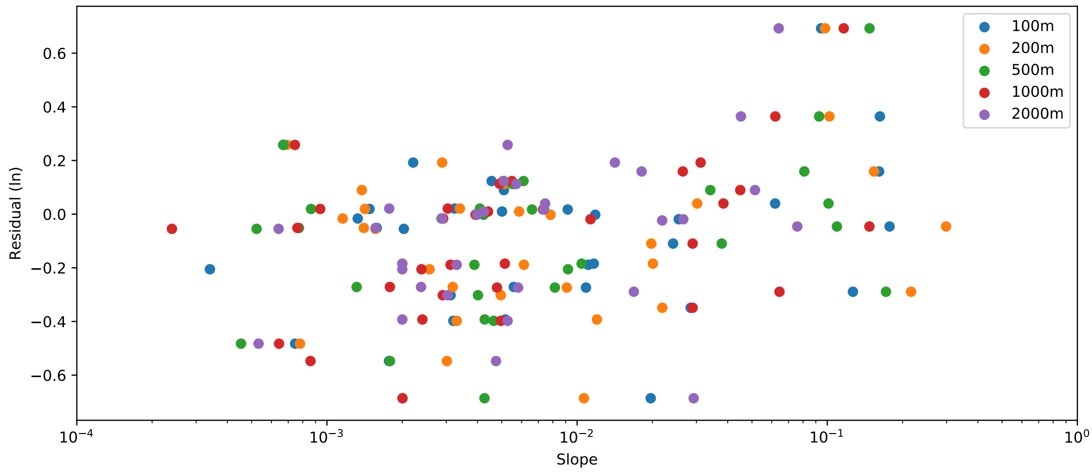


Figure 3.13: Mean residuals for each site plotted against topographic slope, computed at grid resolutions ranging from 100 to 2000 metres.

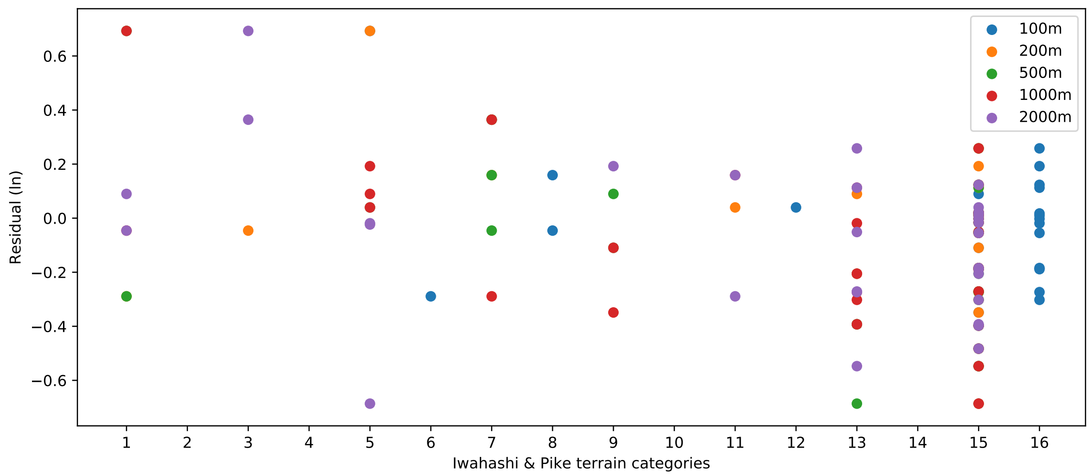


Figure 3.14: Mean residuals for each site plotted against discrete terrain categories (Iwahashi and Pike, 2007), computed at grid resolutions ranging from 100 to 2000 metres.

The number of sites included in this study is too small, and the range of geographic locations and geologic characteristics too clustered, to draw any strong conclusions from these results. Some speculation follows about the origin of this (apparent, weak) trend; it may provide some tentative insights for potential directions for future research. The apparent trends in Figures 3.13 and 3.14 indicate a possible tendency for overprediction of V_{S30} at very flat sites (*e.g.*, Christchurch city and surrounds) and underprediction in mountainous areas, with the best performance seemingly at sites with modest (~ 1 percent) slope. There are far too few sites with steep slope to attempt to guess any physical explanation for the underprediction at those sites. However, the distinction between 10^{-3} or 10^{-4} slopes and 10^{-2} for alluvial deposits is generally associated with distinctly different particle sizes and overall sediment stiffness (Wills and Gutierrez, 2009). In Canterbury, where many of the sites under investigation are located, there is likely a fairly smoothly-varying increase in V_{S30} proceeding from the flat city of Christchurch to the modestly-sloped terrain of the western Canterbury plains, associated with the gradual increase in topographic slope arising from the depositional history of the Canterbury basin. Whether there is something inherent to sites of moderate stiffness that renders them more amenable to the P-wave method, or whether there is a regionally specific tendency in the Christchurch sites (many of which are underlain by the Banks Peninsula Volcanics, which introduce a shear wave velocity reversal and represent a major departure from the simplified assumptions of the P-wave method) is not possible to conclude on the basis of this study alone.

3.8.2 The "negative ratio" issue

The following discussion refers extensively to the ratio $\frac{\dot{U}_R}{\dot{U}_Z}$ (Section 3.5). As before, sometimes this quantity will be called simply the "ratio" or (as it is relevant in this section) a negative/positive ratio. As mentioned, a hypothetical "perfect" site or problem domain would resemble the idealised horizontal, two-layered site shown in Figure 3.3. Similarly, a hypothetical "perfect" ground motion recording would have no noise or baseline drift. Examining Equation 3.1, it is clear that the only way $\frac{\dot{U}_R}{\dot{U}_Z}$ can be negative is if $p^2V_S^2 > 0.5$, which means $\sin^2 j > 0.5$ and $\mid j \mid > 45°$. Since $i > j$ (because $V_P > V_S$), this implies a very shallow arrival angle, which while not impossible, is rare (because shear wave velocity tends to increase with depth, meaning seismic waves generally refract toward the vertical at impedance boundaries: Shearer, 2019). In short, for *idealised* applications of the P-wave method, the ratio $\frac{\dot{U}_R}{\dot{U}_Z}$ can always be expected to be positive.

By contrast with the idealised case, negative ratios are not uncommon in actual ground motion recordings considered herein. Following the reasoning above, negative ratios may be associated with non-ideal (noisy) earthquake recordings, non-ideal sites (in areas with complex geologic structures or terrain), or both. This suggests some utility in evaluating the proportion of records with negative ratios for a given site.

It should be emphasised that for all V_{S30} estimates presented in this work, whether by manual or automated approaches, negative ratios were *discarded* as mentioned in Section 3.5. $\frac{\dot{U}_R}{\dot{U}_Z} < 0$ is treated as a possible indirect (and insufficient) indicator of the *applicability* of the P-wave method, but records with negative ratios are not shown in any of the results in Figures 3.6-3.11 or elsewhere. Of course, the absence of statistically significant numbers of negative ratios itself is also not a sufficient indicator of "good" results.

In Appendix D there is a short discussion on the alternative functional forms for Equation 3.4 to find V_S and V_{S30}, where the sign of $\frac{\dot{U}_R}{\dot{U}_Z}$ is relevant. The rest of this section contains more detailed discussion on the question of negative ratios, and a few exemplary sites where negative ratios may be the result of departures from ideal-site assumptions.

As mentioned above, in general it is assumed that negative ratios arise for either non-ideal geometry, noisy recordings, or both. When considering only sites with ideal or near-ideal geometry, and when considering only automated pulse-picking and baseline correction, it can be assumed that $\frac{\dot{U}_R}{\dot{U}_Z} < 0$ is an artifact of noise, baseline drift and/or other more-or-less random complications attendant to automated pulse-picking, and not physically meaningful. It is intuitive to expect that among the noisiest ground motion records, roughly 50% of records would have negative ratios and half would be positive.[6] So, the proportion of negative to positive ratios (obtained via automated approaches) might be useful as a screening tool for evaluating whether a particular site is sufficiently close to the idealised assumptions above for the P-wave method to yield realistic V_{S30} estimates. This would indicate sites for which the vertical and radial components tend to be out of phase systematically and $\frac{\dot{U}_R}{\dot{U}_Z} < 0$ occurs more than mere chance would suggest. Indeed, in the course of manual pulse picking, a few sites did appear to exhibit radial and vertical velocity traces that were frequently or consistently out of phase. This behaviour inspired a closer look at these sites.

Each pane in Figure 3.15 presents the number of records for which the automated LBC and pulse picking method yielded positive $\frac{\dot{U}_R}{\dot{U}_Z}$ ratios, and the number of negative ratios. These values are plotted as integers above and below zero, respectively, binned by SNR. For stations where the "layer cake" assumptions are sufficiently close to reality, there will be roughly 100% positive ratios at the high end of the SNR continuum. In Figure 3.15 the left-side panes represent three stations where we hypothesise that the P-wave work method works well because local geology is fairly close to idealised assumptions. For Templeton (TPLC), Papanui (PPHS) and North New Brighton (NNBS), Figure 3.9 shows that there is good precision and little or no bias evident in the residuals, and there is little change from the 1D to 2D case. The stations chosen for the right-side panes are examples of sites where the P-wave method yields poor precision and/or accuracy, and/or where there is a significant difference between the 1D and 2D cases, which suggests non-ideal geometry. These non-ideal sites are all located on or near the steep volcanic terrain of the Banks Peninsula (Figure 3.16). Discrepancy between the 1D and 2D approaches does not indicate per se that the P-wave method does not or cannot yield useful V_{S30} estimates; merely that the 1D approach may be inadequate for sites with non-ideal geometry.

[6]Where pulse picking is done manually, using the interface shown in Figure 3.5 or similar, the user's predilection for "sensible-looking" radial and vertical arrival pulses becomes relevant and the 50% figure cannot be assumed. It is therefore simpler, faster and more appropriate to use automated methods for evaluating the prevalence of negative ratios.

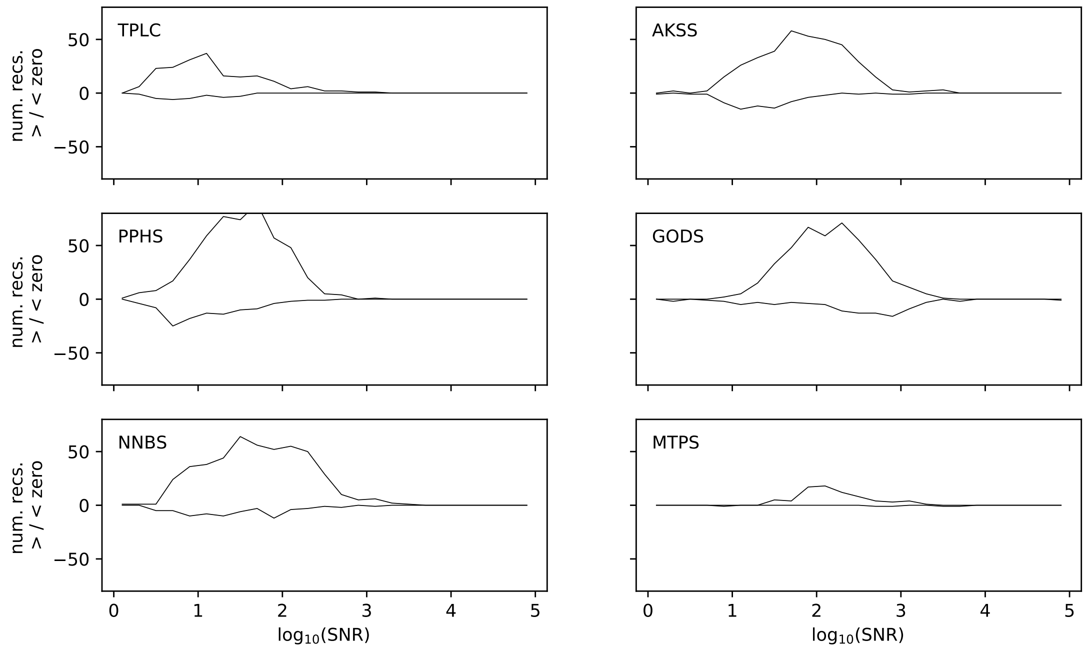


Figure 3.15: For ground motions binned by SNR, the total number of motions at each station for which automated LBC yields $\frac{\dot{U}_R}{\dot{U}_Z} > 0$ and < 0 are plotted as negative and positive lines, respectively. The three stations on the left side of the figure are chosen because they may have "ideal" properties; the three on the right are non-ideal.

Akaroa School (AKSS) is located near the foot of a steep volcanic hillside (Figures 3.16 and 3.17). The idealized layer cake assumption clearly does not apply. In fact, many recordings at AKSS display a "signature" tendency for the vertical and radial velocity traces to be nearly 180° out of phase (Figure 3.18). However, it is also common for the first vertical peak to coincide with a positive $\frac{\dot{U}_R}{\dot{U}_Z}$ ratio; consequently, there is not a significant number of negative $\frac{\dot{U}_R}{\dot{U}_Z}$ ratios in Figure 3.15.

Godley Head (GODS) is located near the top of the Port Hills, the western side of the Banks Peninsula nearest Christchurch. (Figures 3.16, 3.19). As with AKSS, it is obvious that the local site conditions at GODS are nothing like the idealised conditions. Unlike at AKSS, a significant proportion of GODS records with high SNR have negative ratios (Figure 3.15). But not all low-noise recordings from GODS have negative ratios; most are still positive. Figure 3.20 shows two prototypical examples of recordings from GODS.

Figure 3.16: "Non-ideal" sites AKSS, GODS, and MTPS, shown with aerial imagery for geographic context. Small boxes in inset show location of subsequent figures (3.17 and 3.19).

Figure 3.17: Akaroa School (AKSS) strong-motion station location.

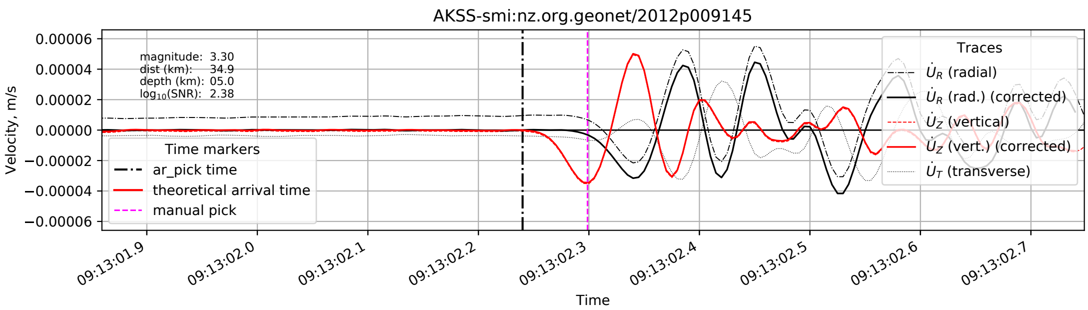


Figure 3.18: AKSS

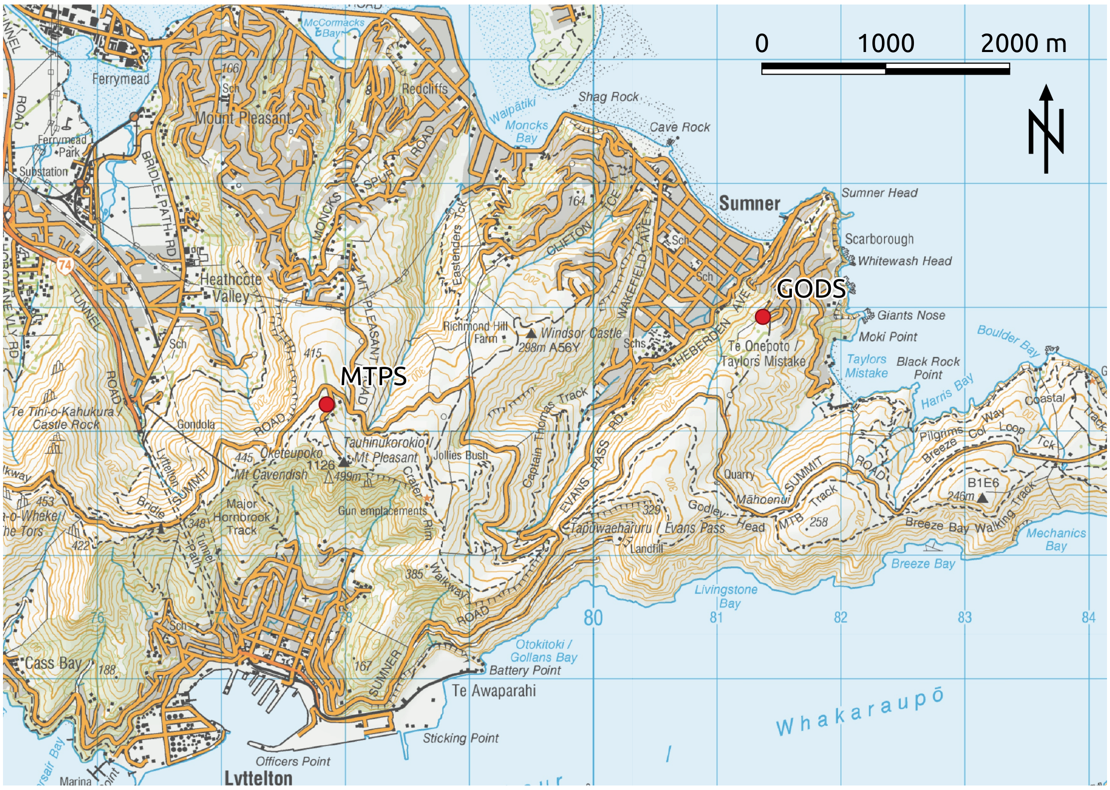
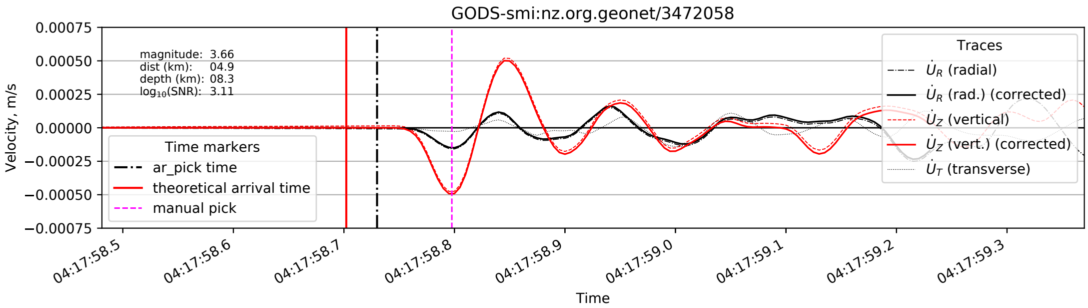


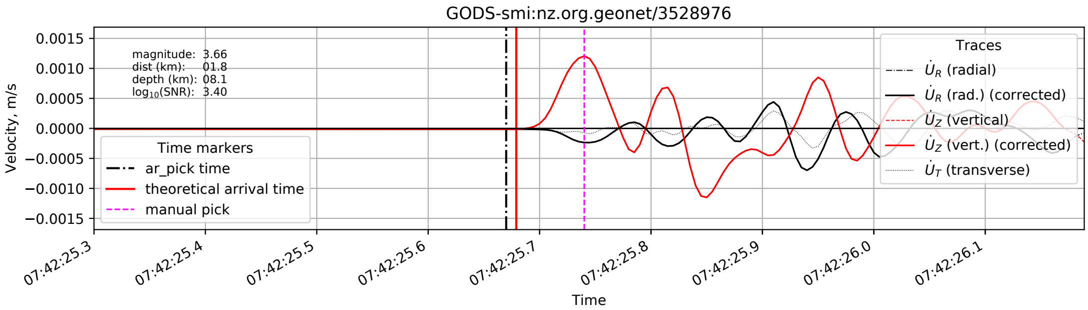
Figure 3.19: Godley Head (GODS) and Mount Pleasant (MTPS) strong-motion station locations.

Like GODS, MTPS (Mount Pleasant) is a strong motion station located in the Port Hills. MTPS has far fewer triggered event recordings than the others shown in Figure 3.15, and none have negative ratios. Nevertheless, it is clear from the topography (Figure 3.19) that it is not an ideal site. Figure 3.21 shows a typical record from MTPS, which exhibits a minor phase shift between the vertical and radial components of the first arrival.

Other non-ideal stations were examined in detail besides those discussed above. Among these, the most obvious non-ideal characteristics were topographic. Some stations, such as SHLC (Shirley Library) are characteristically noisy and did not yield good V_{S30} estimates. SHLC is installed in a busy parking structure. Close examination of all SHLC records indicates that the vertical P-wave arrivals were generally discernable, but the horizontal arrivals were nearly indistinguishable from noise. However, ratios from SHLC were more than 50% negative: it is possible, though far from clear, that this is a systematic effect related to the



(a) A positive-valued ratio from an event originating 5km to the northwest and 8 kilometres deep.



(b) A negative-valued ratio from an event originating less than 2km to the southeast and also 8 kilometres deep.

Figure 3.20: Prototypical examples of (a) positive- and (b) negative-valued $\frac{\dot{U}_R}{\dot{U}_Z}$ ratios measured at Godley Head station (GODS).

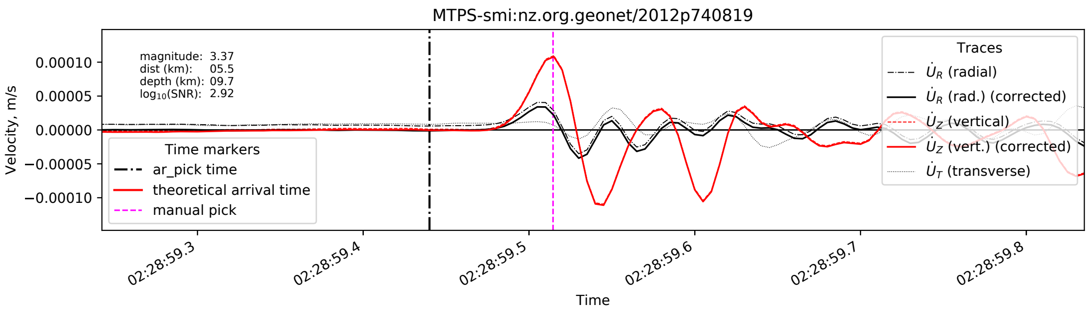


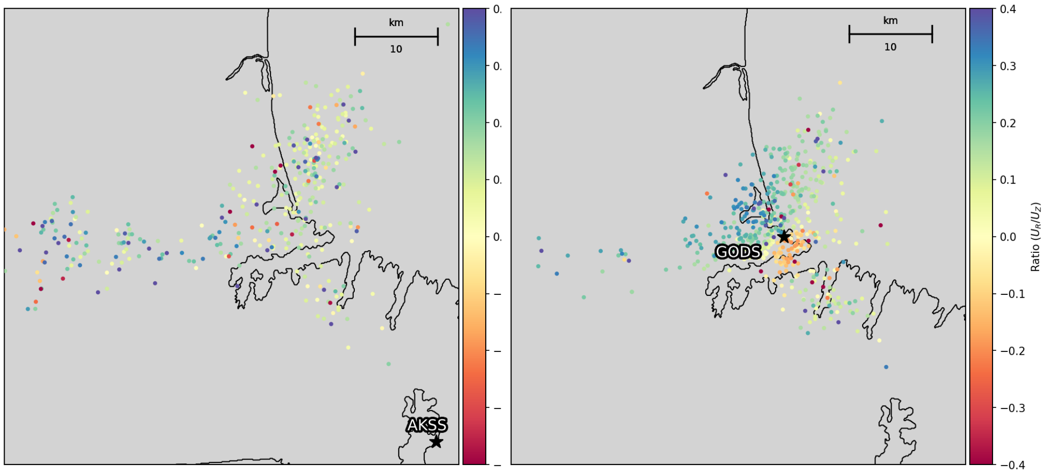
Figure 3.21: MTPS

structural response of the parking garage.

Since the systematically out-of-phase vertical and horizontal pulses at certain stations are hypothesized to be associated with topographic effects (at least sometimes), it is worth examining whether there is any trend of ratio with source azimuth. Figure 3.22 presents plan views of AKSS and GODS with all earthquake epicentres shown as colored dots, with the color determined by the value of automatically-picked ratios. Ratios from recordings at Akaroa School (AKSS) tend to be higher-valued for earthquakes originating south of Christchurch city (roughly the left side of the region shown), compared with the rest of events, most of which originated on the east side of the city (roughly the upper-right quadrant of the region shown). Recordings at Godley Head (GODS) show a very strong correlation between ratio and epicentral location, with higher positive-valued ratios associated with most events originating to the northwest of the station (beneath Christchurch city) and near-zero and negative-valued ratios associated with most events originating to the southwest of the station. This directionality corresponds to the dominant orientation of the ridge where GODS is situated (Figure 3.19), supporting the hypothesis that topographic effects are significant here. Figure 3.23 shows the 1-D and 2-D residuals computed for GODS. (Figures 3.20a and 3.20b were chosen to illustrate the typical differences in motions observed from events with epicentres to the northwest and southeast of GODS, respectively). The 2-D approach to V_{S30} estimation reduces the strong directionality somewhat, though not entirely. This would be an expected result if it is assumed that poor P-wave method performance can be attributed to a departure from ideal (horizontal) conditions in both the ground surface (observable from topography) and the basement (observable in the NZVM, and handled by the 2-D approach).

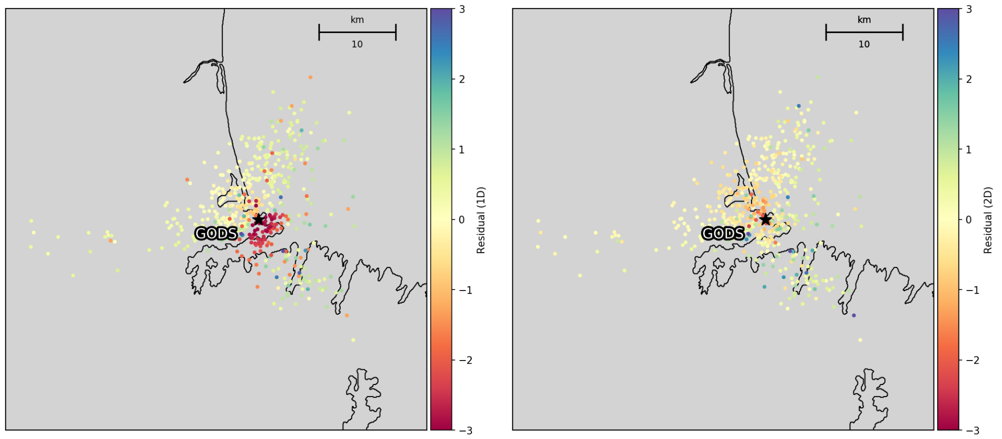
3.9 Conclusion

The P-wave method is a simple but reasonably effective approach to estimating V_{S30} using weak earthquake recordings. This study evaluated the performance



(a) Akaroa School (AKSS) (b) Godley Head (GODS)

Figure 3.22: Earthquake epicentres are shown as colored dots. Color is based on ratio. (Map background colour is intentionally uniform to reduce difficulty in interpretation of the plotted points.) Both AKSS and GODS show a correlation between source azimuth and ratio.



(a) 1-D residuals (b) 2-D residuals

Figure 3.23: Earthquake epicentres for recordings at GODS, shown as colored dots. Color is based on (a) 1-D or (b) 2-D residual. The directionality associated with source azimuth is reduced by the 2-D approach, albeit not entirely.

of the method at 36 strong motion stations in New Zealand where V_{S30} measurements from surface wave testing were available. From about 12,000 records in total, a subset of about 3,000 records were manually evaluated and processed, and the results were compared with automated baseline-correction and pulse picking for both one- and two-dimensional variants of the P-wave method.

Conclusions indicated that there is a tendency for overprediction of V_{S30} by the method for noisy records, particularly with the 1D approach, where depth to the major refraction point directly beneath the site is assumed representative for all hypocentral locations. A 2D variant, where the refraction location is estimated based on a profile extracted from 3D regional velocity models, performs better (in terms of both accuracy and precision) than the 1D approach. There is no substitute for manual examination of individual ground motion records, but the automated LBC approach to computing $\frac{\dot{U}_R}{\dot{U}_Z}$ ratios performs well where many good-quality motions are available.

A minor adjustment to the automated LBC technique from Kang et al. (2020) (adjusting the velocity traces by subtracting a linear trend, rather than a constant, based on the 0.5 seconds of noise preceding the automatically-picked P phase) yielded incrementally better results (as measured by precision in time) for the problem of automated pulse picking. The resulting V_{S30} estimates did not differ in a statistically significant way from the Kang et al. (2020) approach.

When the residuals are plotted against takeoff angle, the trend corroborates the findings of Kang et al. (2020): significant overprediction at near-vertical takeoff angles. This has an inconsequential impact on the evaluated model performance herein since there are relatively few earthquake recordings with very small takeoff angles. This may be useful in forward prediction, especially for sites with few useable records.

A collection of "best estimate" residuals was assembled for both the 1- and 2-dimensional approaches, with the median residuals from each site. These were compared with the residuals for V_{S30} estimates obtained from the global slope-based model by Allen and Wald (2007) in order to ascertain how these two P-wave method variants performed by comparison with a widely-used proxy-based model. The residuals' smoothed kernel density estimates were shown in Figure 3.10 and their statistics summarised in Table 3.2. The results suggest that for the sites examined in New Zealand, the 1-D P-wave method performs similarly to, or slightly worse than, the slope-based Allen and Wald (2007) model, while the 2-D variant outperforms the slope-based model. These results are still tentative and limited by the range of sites that have V_{S30} measurements and can be used for model validation. But given the time- and data-intensive requirements of applying the P-wave method, for most practical applications, at present the geologic and terrain correlations used in models such as Allen and Wald (2007) and Foster et al. (2019) offer a more straightforward and robust strategy for estimating V_{S30}. These conclusions can be easily re-evaluated in the near future, as detailed site characterisation of additional NZ strong motion stations is underway.

Some tentative investigation into the problem of discriminating between "good" and "bad" sites (in terms of their amenability to V_{S30} prediction using the P-wave method) was presented. There is a weak, and perhaps coincidental, apparent trend between slope and site-specific residuals. Some limited insight can be gained by taking note of the relative amounts of negative-values $\frac{\dot{U}_R}{\dot{U}_Z}$ ratios for a given site, but this information is of little practical significance without more detailed assessment of other known aspects of a strong motion site (such as the local terrain and geology, knowledge of noise sources and any possibility of structural or topographic resonances).

3.10 Data, Resources and Acknowledgments

All data used in this paper came from published sources listed in the references, with the exception of the value of V_{s30} and associated uncertainty provided by Andrew Stolte (personal communication) from a recent suite of surface wave testing inversions yet to be published.

The authors are grateful to the University of Canterbury's QuakeCoRE ground motion simulation computational team for helpful advice and support, including Jonney Huang, Sung Bae, James Paterson, Viktor Polak, Jason Motha, and Claudio Schill. Andrew Stolte, Adnan Djeffal, Vahid Loghman and Chris de la Torre gave helpful insights and feedback. We acknowledge GNS Science, the New Zealand GeoNet project, and its sponsor EQC (Earthquake Commission), as well as LINZ (Land Information New Zealand) and Landcare Research, the providers and maintainers of geographic information resources used herein.

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Chapter 4

Concluding remarks

In Chapters 2 and 3 two distinct approaches for estimating V_{S30} were applied in New Zealand. Some key insights are summarised again here with a few miscellaneous notes, followed by comments on some natural directions for future work that builds on these findings.

4.1 Summary of Key Findings

Chapter 2 represents an update of the V_{S30} map for New Zealand that was first developed by Perrin et al. (2015), with some significant improvements. The new model includes explicit assumptions about the major sources of quantifiable uncertainty and a map of this uncertainty alongside the V_{S30} model itself. It attempts to incorporate insights from terrain-based V_{S30} modelling (*e.g.* Allen and Wald, 2007; Yong et al., 2012) as well as the geology-based approaches that are most commonly employed for proxy-based V_{S30} modelling, and applies Bayesian methods to merge these two distinct models in a consistent way. Similarly, a transparent geostatistical technique is used to handle geographical interpolation and extrapolation in the vicinity of measurements, including explicitly assumed measurement uncertainty. This reduces sharp fluctuation of the model predictions over short distances, which is a problem with conventional kriging wherever nearby measurements disagree. Thus the novel scientific contributions in Chapter 2 are the application/update for New Zealand, the rigor of the Bayesian and multivariate normal (MVN) geostatistical approaches, the pairwise covariance reduction factor (CRF) to avoid overconfident extrapolation of normalised residuals across sharp lateral discontinuities in the mapped surface geology, and the establishment of a flexible framework with which other researchers can develop new and updated V_{S30} models with comparatively little effort. To this end, projects are already underway in Brendon Bradley's research group at the University of Canterbury (Bae, Motha, Polak, Stolte, de la Torre, McGann, *et al.*, personal communication).

As is typical for V_{S30} the lognormal uncertainty σ increases with V_{S30}. The detail of the model is finer than many similar models since the terrain categories are derived from a 100-metre sampling of the digital elevation model (DEM). This should not be construed as implying greater accuracy than is justified by the input data and assumptions discussed in Chapter 2. Nevertheless, the continuous closely-spaced map grid does allow for judicious visual interpretation of the V_{S30} estimates including their degree of variation across distances that are representative of the problem at hand.

Chapter 2 has been published in the journal *Earthquake Spectra* (Foster et al., 2019). The journal hosts electronic versions of supplemental material—Appendices A and C, as well as high-resolution electronic versions of the nationwide V_{S30} and σ maps. Some researchers have reported difficulty accessing the publication and/or the electronic supplements; at the time of this writing I am also hosting all of these materials on my personal website (Foster, 2021b).

One minor error, brought to my attention by Viktor Polak after the publication of the model, is as follows: The computed slope values in the Canterbury Plains (and other similarly flat alluvial expanses) are slightly inaccurate because of the details of the interpolation algorithm applied when the DEM was created (Barringer et al., 2002; Landcare Research New Zealand, 2010). The elevation values in the DEM appear to have a "stair-step" quality in wide, gently-sloping regions such as the Canterbury Plains, governed by the vertical precision of the data sources underlying the DEM. When the spatial derivative is taken to generate slope values, this results in artifacts that are visually evident in *e.g.* Figure 2.3b and 2.3f as concentric bands of color running parallel to the Southern Alps and stepping seaward from left to right in the figure. The slopes computed in the vicinity of the "stair steps" are a function of the grid dimension. The impact of these artifacts is not significant enough to change the geology- or terrain-based V_{S30} estimates significantly. The detail escaped our (and our reviewers') attention during preparation for publication, probably because the artifacts appear plausibly natural, but since they are not, I mention it here.

In Chapter 3, a variation of the receiver function concept, which had until recently (Ni et al., 2014) been used mostly by seismologists for inference about large-scale subsurface geologic features, was applied at 36 strong motion stations in New Zealand to estimate V_{S30}. This application added to recent work by others (Kim et al., 2016; Hosseini et al., 2016; Zalachoris et al., 2017; Miao et al., 2018; Kang et al., 2020) insofar as it produced V_{S30} estimates at strong-motion stations based on a few simplifying assumptions and a collection of small earthquake recordings. The resulting estimates were validated against recent high-quality surface wave-based assessments of shear wave velocity profiles. Out of about 12,000 recorded motions, a subset of about 3,000 were selected (including both the best available motions at each site and a wide range of signal-to-noise ratios [SNR]) for careful manual examination and local baseline correction (LBC), culling records of poor or ambiguous quality. The V_{S30} estimates derived from these manually-processed records were compared against the corresponding estimates from automated processing of all 12,000 records.

The results suggest that both automated and manual models yield trivial bias for SNR above ~ 1.6, but the precision for the estimates based on manually-processed records is better. There is systematic overprediction for automated estimates below SNR = 1.6. This suggests that human judgment is superior to the simple automated LBC applied for noisy records, and that the automated procedure yields enough erroneously high $\frac{\dot{U}_R}{\dot{U}_Z}$ ratios to induce bias in the results from these records. Since negative ratios are inconsistent with the physical assumptions on which the P-wave method is based, these are discarded, so it is possible this "nudges" the noisy-record bias in only one direction. (The bias induced by retaining negative ratios will be determined in large part by the approach to solving Equation 3.1, as discussed in Appendix D). As discussed in Section 3.6.1, results by Kang et al. (2020) also indicate a tendency for overprediction among noisy records. Importantly, the pulse picking approach employed by Kang et al. (2020) was also automated. In conclusion, for a method that relies heavily on the selection of a single $\frac{\dot{U}_R}{\dot{U}_Z}$value occuring at the precise moment of the first wave arrival for weak earthquakes, there is no substitution for careful manual examination of ground motion records for quality, especially if relatively few, low-SNR records are available.

The LBC approach proposed by Kang et al. (2020), which entails shifting each velocity trace by a constant equal to the average amplitude 0.5 seconds before the first wave arrival, was compared against a variation where a linear fit (rather than constant) was applied. This yielded modest improvements in the automated pick of pulse peak, although this did not give statistically significant improvements in V_{S30}, suggesting that this a second-order effect.

Since the New Zealand Velocity Model (NZVM) (Thomson et al., 2020) includes detailed information about alluvial basin depths, these were leveraged to trial a novel two-dimensional variation on the P-wave method. This yielded significant benefits over the 1-D approach in terms of both precision and bias. The systematic overprediction with automated ground motion processing of noisy records was reduced significantly, although not eliminated.

The performance of the 1-D and 2-D approaches relative to the popular global slope-based V_{S30} model by Allen and Wald (2007) can be seen in the smoothed probability density estimates and statistics presented in Figure 3.10 and Table 3.2.

While the conclusions are still tentative owing to the relatively small collection of 36 stations with V_{S30} measurements available for validation, these comparisons indicate that the 2-D approach confers a nontrivial advantage over proxy-based methods for estimating V_{S30}. The 1-D approach, meanwhile can be seen as performing similarly to or slightly worse than proxy-based methods. (The more robust proxy-based model developed in Chapter 2 was not used for comparison since it was derived using data from many of the same strong motion stations as Chapter 3).

A tendency for overprediction at near-vertical takeoff angles was consistent with the findings of Kang et al. (2020). This trend appears stable enough to justify applying a correction in forward predictions, but this was not done in Chapter 3 because there are so few applicable records that the impact was not statistically significant. Some discussion was provided regarding the possible causes of negative $\frac{\dot{U}_R}{\dot{U}_Z}$ ratios and their physical meaning. Since one cause (at least for certain stations) appears to be systematic phase shifts between the first vertical and radial pulses, and since this can be caused by topographic effects, some investigations were done examining the trends between source azimuth and ratio, and between source azimuth and prediction residual. The source azimuth is hypothesized to correlate with bias because of preferential direction of vibration for topographic features with anisotropy in plan view. Although the 2-D variant of the P-wave method does seem to promise a reduction in the bias that arises for certain stations at certain source azimuths, it also clearly does not eliminate the issue, nor would it be expected to. The P-wave method does not and cannot account for topographic effects. The recommendation for forward prediction is to apply the method only at sites where the simplified/idealised site assumptions can be considered reasonably representative of reality.

4.2 Future Research

There are a few avenues open for expansion of the work that has been presented in this thesis. The V_{S30} modelling from Chapter 2 is intended to be updated with new data. Surface wave testing has proceeded apace since the publication of Foster et al. (2019), led primarily by Liam Wotherspoon and Andrew Stolte. The reduced V_S profiles from recent testing can be incorporated into a new version of the V_{S30} map. The predictions developed in Chapter 3 can also be added to the next version of the map. Among these, there are also V_{S30} values from new surface wave testing results (*e.g.*, Cox and Vantassel, 2018) and/or values from older data that were not added to the Foster et al. (2019) model for stations AKSS, LPCC, NBLC, MGCS, LHUC, and PIPS.

Additionally, an extension of the study in Chapter 3 is planned that will develop V_{S30} estimates for a number of stations where validation data are not yet available. This has the potential (pending the quality of ground motion recordings at each station, which will vary) to expand the number of V_{S30} values at strong motion stations on the order of about 100 stations as summarised in Table 4.1.

Table 4.1: Summary of currently-available mapped sedimentary basins and number of permanent strong motion stations within each.

Basin name	Number of stations
Cheviot	3
Hanmer	1
Kaikoura	6
Marlborough	17
Nelson	15
North Canterbury	7
Waikato-Hauraki	12
Wellington	59

Appendix A

V_{S30} measurements

In this appendix the V_{S30} data and/or measurements used to develop the model in Chapter 2 are presented in tabular form. The data correspond to the discussion in Section 2.3.2.

Lat	Lon	Vs30	sigma_meas.	Location ID (if present)	Data source	Qflag	Region (QMAP quadrant)
-43.291569	172.714373	220.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.304781	172.606226	225.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.307775	172.641398	185.6	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.300348	172.680375	160.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.309414	172.700931	199.9	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.307950	172.605912	227.9	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.312292	172.625507	200.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.312292	172.625507	200.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.316725	172.666176	151.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.312914	172.699869	200.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.312998	172.700026	213.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.329064	172.667753	180.7	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.329175	172.667762	170.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.334813	172.681705	184.8	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.328956	172.685334	217.8	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.355683	172.664438	209.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.351851	172.676969	214.9	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.357683	172.664722	209.7	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.372360	172.668385	257.6	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.370600	172.698434	196.2	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.370628	172.698693	194.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.375770	172.632733	259.8	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.380924	172.642402	205.7	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.379962	172.653476	208.9	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.378611	172.665096	223.6	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.380526	172.673111	237.6	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.376582	172.703006	172.0	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.382671	172.630709	210.7	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.387448	172.645153	206.8	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.384741	172.657056	198.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.385894	172.667663	210.6	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.386119	172.673357	206.4	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.386202	172.703096	190.8	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.393317	172.642431	181.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.394084	172.658973	203.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.393943	172.661192	201.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.399631	172.693299	187.7	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.397325	172.701158	191.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.403076	172.644162	175.9	0.2	NA	McGann et al. (2017)	NA	Christchurch

-43.403220	172.650239	208.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.404541	172.667903	202.4	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.406850	172.693864	202.0	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.402828	172.701121	191.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.414380	172.605116	207.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.411652	172.646954	173.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.411341	172.647971	169.9	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.413022	172.692756	206.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.423735	172.654082	201.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.425712	172.690262	202.6	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.434764	172.646424	175.7	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.430833	172.650331	202.2	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.435677	172.677851	196.9	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.430711	172.692751	192.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.430665	172.701470	194.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.444593	172.633898	165.9	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.437562	172.645679	180.8	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.437414	172.647138	182.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.441150	172.665996	194.4	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.435874	172.677987	196.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.434788	172.695304	185.9	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.450541	172.611360	171.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.448796	172.616995	166.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.449766	172.632835	137.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.447231	172.641276	194.0	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.451396	172.649906	176.4	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.445110	172.666674	211.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.461120	172.609337	196.2	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.457635	172.619786	180.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.458712	172.622252	169.8	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.454537	172.643244	169.2	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.457274	172.653340	224.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.459647	172.666192	208.9	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.470743	172.610908	188.7	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.469948	172.615909	180.7	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.464900	172.634530	164.4	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.466710	172.642996	153.6	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.464813	172.653682	212.0	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.467096	172.666883	203.2	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.471565	172.704101	197.8	0.2	NA	McGann et al. (2017)	NA	Christchurch

-43.479317	172.582265	193.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.479485	172.588231	180.8	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.477254	172.607364	196.2	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.476259	172.615172	167.6	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.474582	172.629785	200.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.476630	172.666125	206.7	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.473903	172.677766	204.4	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.476390	172.691768	182.8	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.476241	172.703515	180.4	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.476098	172.714195	210.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.483588	172.573714	199.8	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.484087	172.581364	209.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.483863	172.591510	185.6	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.480251	172.608208	174.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.488040	172.620745	160.9	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.483334	172.629670	174.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.483758	172.668089	203.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.484549	172.679649	192.2	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.488806	172.689554	180.7	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.485695	172.703360	193.0	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.487110	172.715646	207.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.493866	172.591093	176.6	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.494423	172.604164	163.8	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.491979	172.618748	176.7	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.497066	172.631161	184.8	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.498310	172.641899	175.9	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.494301	172.658665	212.2	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.491567	172.666230	224.2	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.497661	172.676950	186.2	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.494540	172.691189	188.7	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.493991	172.705307	185.2	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.494114	172.716603	199.0	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.490824	172.723562	205.0	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.502841	172.542524	205.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.507569	172.592543	217.6	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.503910	172.604849	190.0	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.502737	172.617001	175.0	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.502581	172.628048	175.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.502627	172.642838	181.4	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.503099	172.653774	179.7	0.2	NA	McGann et al. (2017)	NA	Christchurch

-43.500011	172.665404	198.2	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.503149	172.677544	179.9	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.503440	172.691969	168.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.502749	172.703751	197.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.503465	172.715921	185.7	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.509462	172.544074	225.4	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.513243	172.570869	196.9	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.512282	172.582344	194.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.510770	172.591135	234.9	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.513671	172.607019	209.4	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.512299	172.616471	175.2	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.514469	172.629037	181.9	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.512260	172.641987	192.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.512010	172.654476	193.9	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.512082	172.666601	194.4	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.512821	172.679782	174.8	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.512523	172.690953	186.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.512330	172.703655	190.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.511901	172.715789	175.6	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.512466	172.729638	194.4	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.521683	172.582225	205.0	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.522350	172.592162	209.7	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.520968	172.604272	201.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.521360	172.617582	212.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.521761	172.629069	178.2	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.520443	172.641148	178.2	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.520321	172.654760	184.2	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.520489	172.667666	166.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.520693	172.678448	193.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.521723	172.691230	192.2	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.519369	172.704435	192.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.519341	172.712252	186.4	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.525123	172.737221	199.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.531202	172.571207	167.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.526804	172.584422	177.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.530772	172.596040	183.6	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.529741	172.603723	162.0	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.526891	172.619776	194.7	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.530837	172.630526	169.2	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.530640	172.641358	182.6	0.2	NA	McGann et al. (2017)	NA	Christchurch

-43.528812	172.651313	202.8	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.533203	172.668980	180.9	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.530218	172.677526	184.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.531076	172.695263	183.9	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.532799	172.702454	184.4	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.526739	172.731564	202.8	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.533733	172.738682	180.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.544310	172.502597	245.6	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.539732	172.544332	216.8	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.540274	172.549363	204.0	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.538205	172.583544	202.6	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.539779	172.593979	181.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.539210	172.611196	173.2	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.540468	172.618031	157.6	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.538885	172.629265	183.0	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.538545	172.642594	174.8	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.539083	172.654352	153.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.539165	172.666188	173.7	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.539786	172.677662	191.9	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.538319	172.688858	190.6	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.538863	172.701906	178.2	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.544710	172.502096	244.0	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.544466	172.552265	182.0	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.551726	172.572329	224.4	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.548976	172.580660	183.8	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.549463	172.591456	160.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.552068	172.603459	177.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.549625	172.616235	150.8	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.548779	172.629726	172.9	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.548450	172.642613	165.7	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.548260	172.654477	170.2	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.548265	172.667514	194.7	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.547891	172.678229	197.0	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.549852	172.690971	177.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.548764	172.698491	184.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.559244	172.547771	183.8	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.557857	172.555100	178.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.553719	172.567072	200.4	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.557318	172.582573	185.9	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.556690	172.592343	179.8	0.2	NA	McGann et al. (2017)	NA	Christchurch

-43.557487	172.605942	177.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.558147	172.616553	170.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.557270	172.630816	192.9	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.556346	172.640706	164.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.557209	172.652871	181.7	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.556484	172.666067	173.8	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.557524	172.677637	196.8	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.555557	172.687854	185.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.557209	172.702696	198.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.569187	172.540750	181.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.565594	172.555699	184.4	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.564128	172.560824	181.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.570636	172.579476	189.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.567162	172.588930	162.0	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.565787	172.603614	155.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.566704	172.622022	174.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.565642	172.629798	240.8	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.567367	172.641221	156.6	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.563147	172.648662	198.4	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.562634	172.663265	164.7	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.561090	172.678734	192.4	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.564678	172.690342	164.4	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.561566	172.740235	174.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.579989	172.520947	232.8	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.573158	172.538106	193.8	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.575632	172.542913	201.6	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.576718	172.553217	190.6	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.574088	172.565172	177.9	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.574483	172.580007	169.2	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.575894	172.599417	221.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.575894	172.599417	221.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.573523	172.616989	153.9	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.573153	172.645489	233.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.573153	172.645489	233.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.570315	172.690379	244.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.572092	172.696642	249.6	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.583968	172.516068	258.8	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.581773	172.536044	201.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.581087	172.545080	180.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.586459	172.551582	188.0	0.2	NA	McGann et al. (2017)	NA	Christchurch

-43.583632	172.569888	199.9	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.580922	172.578194	175.4	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.592978	172.474138	245.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.593107	172.544130	185.4	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.593935	172.553133	192.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.593076	172.568394	172.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.597231	172.603649	166.8	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.605821	172.560937	209.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.605821	172.560937	209.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.597374	172.603350	169.7	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.606127	172.561332	193.4	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.632886	172.558665	195.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.642823	172.501234	193.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.640001	172.556507	187.7	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.635842	172.561250	196.9	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.644176	172.499884	191.5	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.644285	172.502127	191.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.647086	172.554949	171.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.660034	172.510553	190.7	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.660286	172.537576	192.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.658756	172.554126	173.8	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.668740	172.506471	196.1	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.661920	172.532629	199.9	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.664179	172.545009	194.3	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.663434	172.552655	189.4	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.674202	172.499947	195.6	0.2	NA	McGann et al. (2017)	NA	Christchurch
-43.674103	172.500205	178.6	0.2	NA	McGann et al. (2017)	NA	Christchurch
-39.499953	176.875497	150.0	0.2	014A	Kaiser et al. (2017)	Q2	Hawkes Bay
-38.666239	178.022714	138.0	0.2	017A	Kaiser et al. (2017)	Q2	Raukumara
-38.664039	178.024914	138.0	0.2	018A	Kaiser et al. (2017)	Q2	Raukumara
-39.584949	174.273465	210.0	0.2	025A	Kaiser et al. (2017)	Q2	Taranaki
-45.898396	170.509285	140.0	0.2	044A	Kaiser et al. (2017)	Q2	Dunedin
-39.033745	177.423506	155.0	0.2	096A	Kaiser et al. (2017)	Q2	Hawkes Bay
-41.297488	174.780964	245.0	0.2	132A	Kaiser et al. (2017)	Q2	Wellington
-41.234987	174.917066	350.0	0.2	249A	Kaiser et al. (2017)	Q2	Wellington
-39.933758	175.052973	250.0	0.2	302A	Kaiser et al. (2017)	Q2	Taranaki
-41.201086	174.954667	190.0	0.1	468A	Kaiser et al. (2017)	Q1	Wellington
-42.948319	171.566815	300.0	0.2	505A	Kaiser et al. (2017)	Q2	Greymouth
-41.224086	174.879366	200.0	0.2	608A	Kaiser et al. (2017)	Q2	Wellington
-41.234987	174.917166	350.0	0.1	642A	Kaiser et al. (2017)	Q1	Wellington

-41.234087	174.917966	350.0	0.1	642E	Kaiser et al. (2017)	Q1	Wellington
-41.257087	174.948166	120.0	0.1	646A	Kaiser et al. (2017)	Q1	Wellington
-41.256287	174.947966	120.0	0.1	646B	Kaiser et al. (2017)	Q1	Wellington
-41.287088	174.777964	473.6	0.2	647A	Kaiser et al. (2017)	Q2	Wellington
-41.287518	174.776944	473.6	0.2	647D	Kaiser et al. (2017)	Q2	Wellington
-41.204686	174.923266	330.0	0.2	651A	Kaiser et al. (2017)	Q2	Wellington
-41.292088	174.778964	267.0	0.2	900B	Kaiser et al. (2017)	Q2	Wellington
-41.277554	174.779258	275.2	0.2	902A	Kaiser et al. (2017)	Q2	Wellington
-41.278787	174.778464	250.0	0.2	907A	Kaiser et al. (2017)	Q2	Wellington
-41.288588	174.776864	358.0	0.2	911A	Kaiser et al. (2017)	Q2	Wellington
-41.326289	174.808464	239.0	0.2	912A	Kaiser et al. (2017)	Q2	Wellington
-41.294988	174.773464	282.0	0.2	914A	Kaiser et al. (2017)	Q2	Wellington
-41.294688	174.774064	270.0	0.2	914C	Kaiser et al. (2017)	Q2	Wellington
-41.294088	174.775664	291.0	0.2	916A	Kaiser et al. (2017)	Q2	Wellington
-41.293588	174.776864	307.0	0.2	919A	Kaiser et al. (2017)	Q2	Wellington
-41.292088	174.778964	272.0	0.2	941A	Kaiser et al. (2017)	Q2	Wellington
-42.948949	171.567735	300.0	0.2	APPS	Kaiser et al. (2017)	Q2	Greymouth
-43.483176	172.530015	435.0	0.1	CACS	Kaiser et al. (2017)	Q1	Christchurch
-43.529347	172.619876	197.0	0.1	CBGS	Kaiser et al. (2017)	Q1	Christchurch
-43.538085	172.647427	182.0	0.1	CCCC	Kaiser et al. (2017)	Q1	Christchurch
-43.535929	172.627523	196.0	0.1	CHHC	Kaiser et al. (2017)	Q1	Christchurch
-43.565618	172.624176	213.0	0.1	CMHS	Kaiser et al. (2017)	Q1	Christchurch
-43.574748	172.623226	900.0	0.2	CRLZ	Kaiser et al. (2017)	Q2	Christchurch
-45.905156	170.470645	500.0	0.2	DUNS	Kaiser et al. (2017)	Q2	Dunedin
-38.666489	178.022674	138.0	0.2	GISS	Kaiser et al. (2017)	Q2	Raukumara
-39.645846	176.842906	182.0	0.2	HCDS	Kaiser et al. (2017)	Q2	Hawkes Bay
-43.579787	172.709423	348.0	0.1	HVSC	Kaiser et al. (2017)	Q1	Christchurch
-39.585139	174.274245	210.0	0.2	HWHS	Kaiser et al. (2017)	Q2	Taranaki
-38.083515	176.709290	220.0	0.2	KAFS	Kaiser et al. (2017)	Q2	Rotorua
-43.376463	172.663768	257.0	0.1	KPOC	Kaiser et al. (2017)	Q1	Christchurch
-41.204980	174.926600	330.0	0.2	LNBS	Kaiser et al. (2017)	Q2	Wellington
-41.314888	174.818435	200.0	0.1	MISS	Kaiser et al. (2017)	Q1	Wellington
-41.202272	174.953755	190.0	0.1	NBSS	Kaiser et al. (2017)	Q1	Wellington
-43.495426	172.717998	204.0	0.1	NNBS	Kaiser et al. (2017)	Q1	Christchurch
-41.224506	174.879436	200.0	0.2	PGMS	Kaiser et al. (2017)	Q2	Wellington
-43.492846	172.606916	180.0	0.1	PPHS	Kaiser et al. (2017)	Q1	Christchurch
-41.249020	174.934133	190.0	0.2	PRKS	Kaiser et al. (2017)	Q2	Wellington
-43.525813	172.682771	196.0	0.1	PRPC	Kaiser et al. (2017)	Q1	Christchurch
-41.224746	174.873917	190.0	0.2	PVCS	Kaiser et al. (2017)	Q2	Wellington
-43.521947	172.635146	155.0	0.1	REHS	Kaiser et al. (2017)	Q1	Christchurch

-43.536172	172.564404	286.0	0.1	RHSC	Kaiser et al. (2017)	Q1	Christchurch
-41.296528	174.781154	246.0	0.1	RQGS	Kaiser et al. (2017)	Q1	Wellington
-43.505337	172.663391	201.0	0.1	SHLC	Kaiser et al. (2017)	Q1	Christchurch
-45.898626	170.509715	140.0	0.2	SKFS	Kaiser et al. (2017)	Q2	Dunedin
-43.467529	172.613861	219.0	0.1	SMTC	Kaiser et al. (2017)	Q1	Christchurch
-41.290588	174.781064	266.7	0.1	TEPS	Kaiser et al. (2017)	Q1	Wellington
-41.275427	174.783054	274.0	0.1	TFSS	Kaiser et al. (2017)	Q1	Wellington
-41.279854	174.778399	250.0	0.2	VUWS	Kaiser et al. (2017)	Q2	Wellington
-41.257397	174.948466	120.0	0.1	WDAS	Kaiser et al. (2017)	Q1	Wellington
-41.274287	174.779264	265.0	0.1	WEMS	Kaiser et al. (2017)	Q1	Wellington
-41.326409	174.809034	239.0	0.2	WNAS	Kaiser et al. (2017)	Q2	Wellington
-43.483165	172.530014	434.8	0.2	Canterbury Aero Club	Wotherspoon et al. (2013)	NA	Christchurch
-43.529339	172.619878	196.8	0.2	Christchurch Botanical Gardens	Wotherspoon et al. (2013)	NA	Christchurch
-43.538085	172.647427	177.0	0.2	Christchurch Cathedral College	Wotherspoon et al. (2013)	NA	Christchurch
-43.535926	172.627520	206.0	0.2	Christchurch Hospital	Wotherspoon et al. (2013)	NA	Christchurch
-43.565617	172.624169	204.8	0.2	Cashmere High School	Wotherspoon et al. (2013)	NA	Christchurch
-43.501571	172.702191	207.0	0.2	Hulverstone Dr Pumping Station	Wotherspoon et al. (2013)	NA	Christchurch
-43.579778	172.709423	352.2	0.2	Heathcote Valley School	Wotherspoon et al. (2013)	NA	Christchurch
-43.376460	172.663760	257.0	0.2	Kaiapoi North School	Wotherspoon et al. (2013)	NA	Christchurch
-43.495419	172.717997	211.7	0.2	North New Brighton School	Wotherspoon et al. (2013)	NA	Christchurch
-43.492842	172.606914	187.0	0.2	Papanui High School	Wotherspoon et al. (2013)	NA	Christchurch
-43.525803	172.682763	196.0	0.2	Pages Rd Pumping Station	Wotherspoon et al. (2013)	NA	Christchurch
-43.521945	172.635150	154.1	0.2	Christchurch Resthaven	Wotherspoon et al. (2013)	NA	Christchurch
-43.536172	172.564404	285.5	0.2	Riccarton High School	Wotherspoon et al. (2013)	NA	Christchurch
-43.505335	172.663394	210.1	0.2	Shirley Library	Wotherspoon et al. (2013)	NA	Christchurch
-43.467529	172.613861	226.0	0.2	Styx Mill Transfer Station	Wotherspoon et al. (2013)	NA	Christchurch
-43.541640	172.655080	288.4	0.2	AMI 2	Cox et al. (2011)	NA	Christchurch
-43.541630	172.655100	261.3	0.2	AMI 3	Cox et al. (2011)	NA	Christchurch
-43.542130	172.654680	201.0	0.2	AMI 4	Cox et al. (2011)	NA	Christchurch
-43.542730	172.653430	194.5	0.2	AMI 5	Cox et al. (2011)	NA	Christchurch
-43.542420	172.652620	197.3	0.2	AMI 6	Cox et al. (2011)	NA	Christchurch
-43.525170	172.725120	189.7	0.2	S New Brighton Bridge	Cox et al. (2011)	NA	Christchurch
-43.506520	172.685830	205.2	0.2	SW AVD 02	Cox et al. (2011)	NA	Christchurch
-43.504250	172.665450	203.6	0.2	SW 6426	Cox et al. (2011)	NA	Christchurch
-43.379320	172.653480	217.5	0.2	SW KAS 40	Cox et al. (2011)	NA	Christchurch
-43.505170	172.659220	174.0	0.2	SW 6409 / SHY09	Wood et al. (2017)	NA	Christchurch
-43.508520	172.687020	180.1	0.2	SW AVD 07	Wood et al. (2017)	NA	Christchurch
-43.498150	172.700250	177.4	0.2	SW BUR 46	Wood et al. (2017)	NA	Christchurch
-43.524350	172.632650	187.5	0.2	SW CBD 21	Wood et al. (2017)	NA	Christchurch
-43.523930	172.612170	175.0	0.2	SW FND 01	Wood et al. (2017)	NA	Christchurch

-43.381320	172.666730	169.0	0.2	SW KAN 03	Wood et al. (2017)	NA	Christchurch
-43.383000	172.659130	205.0	0.2	SW KAN 05	Wood et al. (2017)	NA	Christchurch
-43.380570	172.668710	195.5	0.2	SW KAN 19	Wood et al. (2017)	NA	Christchurch
-43.380870	172.656880	197.0	0.2	SW KAN 26	Wood et al. (2017)	NA	Christchurch
-43.379350	172.648380	206.2	0.2	SW KAS 20	Wood et al. (2017)	NA	Christchurch
-43.528330	172.635320	176.0	0.2	SW Z2-4	Wood et al. (2017)	NA	Christchurch
-43.527630	172.636970	181.4	0.2	SW Z2-6	Wood et al. (2017)	NA	Christchurch
-43.528750	172.642270	191.7	0.2	SW Z4-4	Wood et al. (2017)	NA	Christchurch
-43.574740	172.623220	900.0	0.2	CRLZ	van Houtte et al. (2014)	NA	Christchurch
-43.632534	172.624664	733.0	0.2	D14C	van Houtte et al. (2014)	NA	Christchurch
-43.578401	172.770733	586.0	0.2	GODS	van Houtte et al. (2014)	NA	Christchurch
-43.584671	172.725601	830.0	0.2	MTPS	van Houtte et al. (2014)	NA	Christchurch
-43.489324	172.101112	518.0	0.2	DFHS	Wotherspoon et al. (2016)	NA	Christchurch
-43.586840	172.089292	457.0	0.2	GDLC	Wotherspoon et al. (2016)	NA	Christchurch
-43.538339	171.959848	531.0	0.2	HORC	Wotherspoon et al. (2016)	NA	Christchurch
-43.592773	172.382406	447.0	0.2	ROLC	Wotherspoon et al. (2016)	NA	Christchurch
-43.675208	172.318451	327.0	0.2	SLRC	Wotherspoon et al. (2016)	NA	Christchurch
-43.550297	172.472808	398.0	0.2	TPLC	Wotherspoon et al. (2016)	NA	Christchurch
-43.622602	172.468765	292.0	0.2	LINC	Wotherspoon et al. (2016)	NA	Christchurch
-43.370714	172.495167	546.0	0.2	SWNC	Wotherspoon et al. (2016)	NA	Christchurch
-43.750892	172.022959	452.0	0.2	RKAC	Wotherspoon et al. (2016)	NA	Christchurch
-43.505591	172.565624	294.0	0.2	Burnside Park	Cox et al. (2016)	NA	Christchurch
-43.566681	172.623209	222.0	0.2	Cashmere High	Cox et al. (2016)	NA	Christchurch
-43.501391	172.647934	160.0	0.2	Christchurch Park	Cox et al. (2016)	NA	Christchurch
-43.524599	172.648853	211.0	0.2	Fitzgerald	Cox et al. (2016)	NA	Christchurch
-43.546876	172.674017	183.0	0.2	Garrick Park	Cox et al. (2016)	NA	Christchurch
-43.441365	172.620876	223.0	0.2	Groynes	Cox et al. (2016)	NA	Christchurch
-43.536962	172.616054	188.0	0.2	Hagley Park	Cox et al. (2016)	NA	Christchurch
-43.522690	172.575867	297.0	0.2	Ilam Fields	Cox et al. (2016)	NA	Christchurch
-43.530570	172.642643	192.0	0.2	Latimer Square	Cox et al. (2016)	NA	Christchurch
-43.515499	172.685487	186.0	0.2	Porritt Park	Cox et al. (2016)	NA	Christchurch
-43.492047	172.709090	202.0	0.2	QEII Park	Cox et al. (2016)	NA	Christchurch
-43.476662	172.613207	188.0	0.2	Redwood Park	Cox et al. (2016)	NA	Christchurch
-43.534568	172.565783	324.0	0.2	Riccarton High Fields	Cox et al. (2016)	NA	Christchurch

Appendix B

Mapping QMAP metadata to geology categories

In this appendix the correspondence between simplified Ahdi et al. (2017a,b) geology categories used in Chapter 2 and the underlying QMAP metadata is presented. (Refer to Section 2.4.1.) As discussed in the main text, categories were assigned by keyword searches in the text, along with iterative, careful evaluation of the resulting classification. Although great care was taken in the classification process, with such an enormous dataset, undoubtedly improvements are possible.

Five metadata fields from QMAP were used (SIMPLE_NAME, MAIN_ROCK, UNIT_CODE, DESCRIPTION, MAP_UNIT). Each row in the table represents a unique combination of these five fields, and gives the abbreviated category corresponding to Ahdi et al. (2017a,b) and pertinent tables and plots in the chapter, *e.g.*, Figure 2.5, Table 2.1, Figure 2.6.

The table can be accessed digitally at my website.

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Eastern Province) sedimentary rocks	sandstone	?Jtk	massive fine-grained sandstone, well-bedded sandstone and mudstone, broken formation and melange		15_undifSed
Late Cretaceous - Paleogene sedimentary rocks	mudstone	?Kiw	siliceous mudstone, glauconitic sandstone, alternating sandstone and mudstone, minor chert lenses, chocolate shale		15_undifSed
Late Cretaceous - Paleogene sedimentary rocks	mudstone	?Kiw	Siliceous mudstone		15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	?Ktw	Greywacke, argillite, conglomerate	Waioeka greywacke	15_undifSed
Neogene sedimentary rocks	greensand	?Ogws	greensand and mudstone		15_undifSed
Neogene sedimentary rocks	limestone	?Pga	Alternating limestone, sandstone, mudstone and conglomerate		15_undifSed
Neogene sedimentary rocks	mudstone	?Pt	Massive mudstone with interbedded sandstone and large concretions		15_undifSed
Neogene sedimentary rocks	sandstone	?Pu	Fine-grained sandstone, sandy mudstone, concretionary sandstone and limestone		15_undifSed
Neogene sedimentary rocks	limestone	?Puo	Conglomeratic limestone		15_undifSed
Late Pleistocene river deposits	gravel	?Q2al	Well sorted, rounded greywacke gravel in sandy matrix	Ohakea alluvial terrace deposits	16_terrace
Basement (Western Province) igneous rocks	basalt	?Q2al	Spilitic basalt; dolerite and camptonite		18_crystalline
Late Pleistocene lahar deposits	gravel	?Q2ht	Poorly sorted boulders, gravel and sand		15_undifSed
Late Pleistocene igneous rocks	ignimbrite	?Q3o	Non-welded ignimbrite, fall deposits and reworked ignimbrite		18_crystalline
Late Pleistocene shoreline deposits	gravel	?Q5b	beach deposits of marine gravel and sand, with overlying loess deposits	beach deposits	09_beachBarDune

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Neogene sedimentary rocks	mudstone	?eMt	Mudstone and sandstone		15_undifSed
Neogene sedimentary rocks	limestone	?eMtl	limestone		15_undifSed
Neogene sedimentary rocks	limestone	?ePmp	Well cemented limestone, conglomerate and sandstone	limestone	15_undifSed
Neogene sedimentary rocks	mudstone	?ePmz	Fossiliferous mudstone and tuffaceous sandstone	shelf deposits	15_undifSed
Early Pleistocene river and estuary deposits	mudstone	?eQal	Mudstone with tuff, ignimbrite, paleosols, gravel and sand		15_undifSed
Early Pleistocene river, lake and shoreline deposits	gravel	?eQp	lacustrine and fluvial sediments	alluvium	06_alluvium
Allochthonous rocks	sandstone	?lKrp	alternating sandstone, mudstone, conglomerate		15_undifSed
Neogene sedimentary rocks	mudstone	?lMt	mudstone, sandstone		15_undifSed
Neogene sedimentary rocks	limestone	?lMtp	Sandy, shelly limestone		15_undifSed
Neogene sedimentary rocks	limestone	?lPms	Pebbly, barnacle rich limestone and sandstone		15_undifSed
Neogene sedimentary rocks	mudstone	?lPmz	fossiliferous mudstone and tuffaceous sandstone		15_undifSed
Middle Pleistocene - Late Pleistocene lake deposits	silt	?lQlk	Undifferentiated silty pumiceous lake sediments	Q4-6 lake sediments (undifferen*	08_lacustrine
Neogene sedimentary rocks	mudstone	?mMt	mudstone, minor sandstone		15_undifSed
Neogene sedimentary rocks	sandstone	?mMt	alternating sandstone and mudstone, massive mudstone and minor limestone	undifferentiated Middle Miocene	15_undifSed
Neogene sedimentary rocks	mudstone	?mMt~	mudstone, minor sandstone		15_undifSed
Middle Pleistocene river deposits	gravel	?mQal	undifferentiated middle Pleistocene alluvial gravels	alluvial terrace depsilts	16_terrace

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Middle Pleistocene - Late Pleistocene lahar deposits	gravel	?uQh	Poorly sorted boulders, gravel and sand	undifferentiated Quaternary lah*	15_undifSed
Middle Pleistocene - Late Pleistocene glacier deposits	gravel	?uQt	Poorly sorted boulder sized angular to subangular clasts in stiff clay matrix	undifferentiated Quaternary till	15_undifSed
Basement (Eastern Province) metamorphic rocks	siltstone	CYt2a	Slightly foliated; well-lineated; argillitic siltstone; greywacke sandstone; minor chert-marble-tuff; rare conglomerate; TZ2A	Kakahu semischist	18_crystalline
Basement (Median Batholith) igneous rocks	diorite	Caad	Massive, heterogeneous, fine-coarse grained diorite, monzodiorite, quartz diorite & quartz monzodiorite; minor leuco-tonalite	diorite	18_crystalline
Basement (Median Batholith) igneous rocks	tonalite	Caarp	Variably foliated, med-coarse grained, megacrystic, biotite±muscovite tonalite gneiss. Metased rafts & rare granitic dikes	tonalite	18_crystalline
Basement (Median Batholith) igneous rocks	tonalite	Caau	Very coarse grained, gneissic biotite+hornblende±garnet tonalite with minor quartz diorite and granodiorite	tonalite	18_crystalline
Basement (Median Batholith) igneous rocks	syenogranite	Caczp	Leuco, med-coarse grained, massive to strongly foliated, equi, bio±ms±gt syenogranite;subord granodiorite, tonalite &qtz diorite	granite	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	Cae	Altered coarse grained granodiorite	Echinus Granite	18_crystalline
Basement (Western Province) metamorphic rocks	metaconglomerate	Caef	Mainly pebbly-cobbly metaconglomerate with minor metasandstone; marble at base; metabasalt flow (massive & pillowed) towards top	metaconglomerate	18_crystalline
Basement (Western Province) metamorphic rocks	metasandstone	Caemd	Well bedded, usually graded, quartzofeldspathic metasandstone and metamudstone (siltstone); rare metaconglomerate	metasandstone	18_crystalline
Basement (Western Province) metamorphic rocks	psammite	Caet	Thinly bedded psammite & pelite, subord felsic & basaltic volcanics/volcaniclastics;minor metaconglomerate,marble,calc-silicates	psammite	18_crystalline
Basement (Median Batholith) igneous rocks	syenogranite	Caexp	Fine gr, equigranular, variably foliatied bt±ms±gt syenogranite & alkali feldspar granite with subord quartz monzonite&monzonite	granite	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Median Batholith) igneous rocks	tonalite	Cal	Leuco, med-coarse gr, equi, weak-moderately foliated, bio tonalite; minor quartz diorite & granodiorite. Widespread alteration	tonalite	18_crystalline
Basement (Median Batholith) igneous rocks	granite	Calp	Leuco, fine-medium grained (locally coarse), equigranular, weak to strongly foliated & lineated biotite±garnet granite	granite	18_crystalline
Basement (Median Batholith) metamorphic rocks	granite	Cap	Altered foliated and lineated granite mylonite and orthogneiss	Platform Gneiss	18_crystalline
Basement (Median Batholith) igneous rocks	gabbro	Carg	Med-very coarse gr, massive to weakly foliated hornblende metagabbro & anorthositic gabbro; minor amphibolite and diorite	gabbro	18_crystalline
Basement (Median Batholith) igneous rocks	gabbro	Carg	Med-very coarse grained metagabbro (hornblende replaces pyroxene), pegmatitic in places; relict igneous layering	gabbro	18_crystalline
Basement (Western Province) melange	melange	Cb	Broken formation and mélange with clasts derived from Junction Formation Haupiri Group Devil River Volcanics and chert	Balloon Melange	15_undifSed
Basement (Western Province) melange	melange	Cbh	Broken formation and mélange with megaclasts mainly derived from Heath Volcanics	Heath Volcanics	15_undifSed
Basement (Western Province) melange	melange	Cbj	Broken formation and mélange with megaclasts mainly derived from Junction Formation	Junction Formation	15_undifSed
Basement (Western Province) melange	melange	Cbl	Broken formation and mélange with megaclasts mainly derived from Lockett Conglomerate	Lockett Conglomerate	15_undifSed
Basement (Western Province) igneous rocks	basalt	Cdb	Basalt and basaltic andesite, andesite and dacite intrusives, epiclastics, interbedded sandstone	Benson Volcanics	18_crystalline
Basement (Western Province) igneous rocks	gabbro	Cdc	Layered gabbro, ultramafic rocks, locally serpentinised epidiorite and basalt dikes	Cobb Igneous Complex	18_crystalline
Basement (Western Province) igneous rocks	andesite	Cdh	Andesite and dacite intrusives	Heath Volcanics	18_crystalline
Basement (Western Province) metamorphic rocks	conglomerate	Cdk	Greenschist and volcanic conglomerate	Devil River Volcanics Group	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Western Province) igneous rocks	andesite	Cdm	Tholeiitic andesite and basalt flows and epiclastic deposits	Mataki Volcanics	18_crystalline
Basement (Western Province) sedimentary rocks	sandstone	Cgj	Quartz-mica feldspathic and lithic sandstone and argillite	Junction Formation	15_undifSed
Basement (Western Province) sedimentary rocks	sandstone	Ch	Ankeritic sandstone and dolomitic mudstone; with conglomerate and interbedded felsic volcanics	Haupiri Group	15_undifSed
Basement (Western Province) sedimentary rocks	siltstone	Ch	Undifferentiated siltstone sandstone granule conglomerate	Haupiri Group	15_undifSed
Basement (Western Province) sedimentary rocks	conglomerate	Cha	Polymict pebble conglomerate	Haupiri Group	15_undifSed
Basement (Western Province) sedimentary rocks	conglomerate	Chc	Polymict matrix-rich conglomerate and sandstone. Clasts include red and white chert sandstone and boninitic volcanics	Haupiri Group	15_undifSed
Basement (Western Province) sedimentary rocks	siltstone	Chh	Siltstone and sandstone with interbedded felsic volcanic rocks	Haupiri Group	15_undifSed
Basement (Western Province) sedimentary rocks	siltstone	Chh	Dolomitic mudstone and sandstone with interbedded felsic volcanic rocks.	Haupiri Group	15_undifSed
Basement (Western Province) sedimentary rocks	conglomerate	Chl	Polymict conglomerate and sandstone. Clasts of sandstone volcanics chert diorite gabbro granite limestone serpentinite	Lockett/Peel Conglomerate	15_undifSed
Basement (Western Province) sedimentary rocks	sandstone	Chr	Dolomitic mudstone and ankeritic sandstone, with local conglomerate beds.	Haupiri Group	15_undifSed
Basement (Western Province) sedimentary rocks	sandstone	Chr	Ankeritic sandstone and dolomite; with local conglomerate beds	Haupiri Group	15_undifSed
Basement (Western Province) sedimentary rocks	conglomerate	Chs	Matrix-rich conglomerate and sandstone. Clasts of tholeiitic (Mataki) volcanics sandstone diorite and ultramafics.	Salisbury Conglomerate	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Western Province) sedimentary rocks	siltstone	Cht	Laminated siliceous siltstone graded sandstone with trilobite-bearing limestone olistoliths and debris flow conglomerate	Tasman Formation	15_undifSed
Basement (Karamea Batholith) igneous rocks	diorite	Ckd	Hornblende-biotite quartz diorite	Karamea Suite	18_crystalline
Basement (Western Province) igneous rocks	granite	Ckgfg	Biotite granite; locally containing large K-feldspar megacrysts	Karamea Suite granite	18_crystalline
Basement (Paparoa Batholith) igneous rocks	granite	Ckgwp	Bioitite granite with large K-feldspar megacrysts	Karamea Suite granite	18_crystalline
Basement (Karamea Batholith) igneous rocks	tonalite	Cktmr	White medium-coarse-grained biotite granodiorite-granite	Karamea Suite	18_crystalline
Basement (Median Batholith) metamorphic rocks	orthogneiss	Cmpp	Variably foliated heterogeneous bio±gt tonalite, granodiorite, and monzogranite orthogneiss; metased xenoliths	orthogneiss	18_crystalline
Basement (Western Province) sedimentary rocks	sandstone	Cpa	Quartz-mica sandstone and volcanogenic chert-rich sandstone	Anatoki Formation	15_undifSed
Basement (Western Province) sedimentary rocks	argillite	Cpp	Calcareous trilobite-bearing siltstone carbonaceous shale quartzose sandstone phyllitic siltstone limestone and dolomite	Patriarch/Owen Formation	15_undifSed
Basement (Western Province) metamorphic rocks	schist	Cpw	Hornblende-biotite schist amphibolite and metagreywacke	Wakamarama Schist	18_crystalline
Basement (Western Province) metamorphic rocks	greenschist	Cwb	Greenschist derived primarily from Balloon Melange	Balloon Melange	18_crystalline
Basement (Western Province) metamorphic rocks	greenschist	Cwd	Greenschist derived primarily from Devil River Volcanics	Devil River Volcanics	18_crystalline
Basement (Western Province) metamorphic rocks	greenschist	Cwh	Greenschist derived primarily from Haupiri Group	Haupiri Group	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Western Province) sedimentary rocks	mudstone	Db	Mudstone and fine sandstone with impure limestone rare shellbeds and conglomerate	Baton Formation	15_undifSed
Basement (Western Province) metamorphic rocks	quartzite	De	Quartzite; shale and limestone; locally fossiliferous	Reefton Group	18_crystalline
Basement (Median Batholith) igneous rocks	granite	Dg	Fault bounded sliver of sheared and altered muscovite granite, cut by felsic pegmatite dikes	granite	18_crystalline
Basement (Median Batholith) igneous rocks	granite	Dg	Massive, fine to coarse grained, muscovite-garnet granite, cut by two mica-tourmaline pegmatite dikes	granite	18_crystalline
Basement (Median Batholith) igneous rocks	granite	Dhg	White, medium grained, variably foliated, inequigranular to equigranular, bio+ms±gt granite, granodiorite and tonalite	granite	18_crystalline
Basement (Karamea Batholith) igneous rocks	granite	Dk	Undifferentiated biotite+/-muscovite porphyritic to equigranular granite granodiorite diorite	Devonian intrusions	18_crystalline
Basement (Western Province) igneous rocks	diorite	Dkd	fine-med grained, equigranular, biotite-epidote diorite	Karamea Suite diorite	18_crystalline
Basement (Karamea Batholith) igneous rocks	diorite	Dkd	Biotite diorite megacrystic Kfeldspar granite	Devonian intrusions	18_crystalline
Basement (Karamea Batholith) igneous rocks	granite	Dke	Equigranular biotite-muscovite granite	Devonian intrusions	18_crystalline
Basement (Rangitoto Batholith) igneous rocks	granite	Dkg	Muscovite-biotite granite	Karamea Suite granite	18_crystalline
Basement (Western Province) igneous rocks	granite	Dkg	Muscovite-biotite granite	Karamea Suite granite	18_crystalline
Basement (Karamea Batholith) igneous rocks	granite	Dkg	Muscovite-biotite granite	Karamea Suite granite	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Rangitoto Batholith) igneous rocks	granodiorite	Dkg_b	Slightly - moderately deformed; equigranular to slightly porphyritic biotite granite; titanite/tourmaline accessories locally	Bonar granodiorite	18_crystalline
Basement (Rangitoto Batholith) igneous rocks	granite	Dkg_k	Pale grey to white equigranular biotite granite; undeformed; accessory muscovite garnet & apatite	Kakapotahi granite	18_crystalline
Basement (Rangitoto Batholith) igneous rocks	granite	Dkg_r	Grey equigranular or slightly porphyritic biotite granite; undeformed; locally hydrothermally altered with qtz or CaCO3 veins	Rangitoto granite	18_crystalline
Basement (Karamea Batholith) igneous rocks	granite	Dkgax	Brownish-white foliated muscovite-biotite granite	Karamea Suite granite	18_crystalline
Basement (Western Province) igneous rocks	granite	Dkgba	Light pink medium-grained biotite granite	Karamea Suite granite	18_crystalline
Basement (Karamea Batholith) igneous rocks	granite	Dkgbr	Light pink coarse-grained biotite granite with K-feldspar megacrysts	Karamea Suite granite	18_crystalline
Basement (Karamea Batholith) igneous rocks	granite	Dkgcr	Coarse-grained variably foliated porphyritic biotite granite	Karamea Suite granite	18_crystalline
Basement (Karamea Batholith) igneous rocks	granite	Dkgdu	Leucocratic muscovite-biotite granite with K-feldspar megacrysts	Karamea Suite granite	18_crystalline
Basement (Karamea Batholith) igneous rocks	granite	Dkgha	White medium-coarse-grained foliated biotite-garnet granite	Karamea Suite granite	18_crystalline
Basement (Western Province) igneous rocks	granodiorite	Dkgl	highly foliated to gneissic inequigranular bt+garnet+/-sillimanite granodiorite cut by granite&pegmatite dikes & mylonite zones	Karamea Suite granitoid	18_crystalline
Basement (Western Province) igneous rocks	granite	Dkgl	coarse gr, variably porphyritic Kspar, biotite +/- musc granite, granodiorite, & tonalite; protomylonite close to Alpine Fault	Karamea Suite granitoid	18_crystalline
Basement (Western Province) igneous rocks	granite	Dkgl	Porphyritic Kspar, biotite +/- muscovite +/- garnet granite, leucogranite and pegmatite, minor tonalite	Karamea Suite granitoid	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Western Province) igneous rocks	granite	Dkgl	equigranular-inequigranular, coarse gr, variably porphyritic Kspar, musc +/- biotite leucogranite, minor granodiorite & tonalite	Karamea Suite granitoid	18_crystalline
Basement (Western Province) igneous rocks	granite	Dkgl	equigranular-inequigranular, variably porphyritic Kspar, biotite +/- muscovite granite, granodiorite, and tonalite	Karamea Suite granitoid	18_crystalline
Basement (Western Province) igneous rocks	granite	Dkgl	equi to inequigranular, med grained, variably foliated, biotite-musc granite; protomylonitic close to Alpine F; minor tonalite	Karamea Suite granitoid	18_crystalline
Basement (Karamea Batholith) igneous rocks	granite	Dkgmc	Brown-grey muscovite-biotite granite	Karamea Suite granite	18_crystalline
Basement (Western Province) igneous rocks	granite	Dkgme	Light grey medium-grained muscovite-biotite granite with large Kspar megacrysts	Karamea Suite granite	18_crystalline
Basement (Hohonu Batholith) igneous rocks	granite	Dkgmg	Light-medium grey medium-grained muscovite-biotite granite	Karamea Suite granite	18_crystalline
Basement (Karamea Batholith) igneous rocks	granite	Dkgmo	Fine-medium-grained weakly foliated muscovite-biotite granite	Karamea Suite granite	18_crystalline
Basement (Western Province) igneous rocks	granite	Dkgok	Coarse-grained foliated biotite-muscovite granite-gneiss	Karamea Suite granite	18_crystalline
Basement (Paparoa Batholith) igneous rocks	granite	Dkgok	Coarse-grained foliated biotite-muscovite granite-gneiss	Karamea Suite granite	18_crystalline
Basement (Karamea Batholith) igneous rocks	granite	Dkgos	Biotite granite locally with megacrystic Kfeldspar.	Karamea Suite granite	18_crystalline
Basement (Karamea Batholith) igneous rocks	granite	Dkgos	Fine to medium grained muscovite-biotite granite	Karamea Suite granite	18_crystalline
Basement (Western Province) igneous rocks	granite	Dkgrj	Leucocratic muscovite granite	Karamea Suite granite	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Hohonu Batholith) igneous rocks	granite	Dkgsu	Light medium-grained biotite-muscovite granodiorite	Karamea Suite granite	18_crystalline
Basement (Karamea Batholith) igneous rocks	granite	Dkgwh	Dark grey coarse-grained biotite granite with large K-feldspars	Karamea Suite granite	18_crystalline
Basement (Karamea Batholith) igneous rocks	granite	Dkm	Leucocratic muscovite K-feldspar granite	Devonian intrusions	18_crystalline
Basement (Karamea Batholith) igneous rocks	granite	Dkp	Megacrystic K-feldspar-biotite granite	Devonian intrusions	18_crystalline
Basement (Karamea Batholith) igneous rocks	granodiorite	Dkt	White coarse-grained biotite granodiorite and tonalite	Karamea Suite tonalite/granodior	18_crystalline
Basement (Karamea Batholith) igneous rocks	granodiorite	Dktts	Hornblende diorite	Karamea Suite	18_crystalline
Basement (Western Province) metamorphic rocks	orthogneiss	Dog	Undifferentiated K-feldspar- biotite orthogneiss		18_crystalline
Basement (Western Province) igneous rocks	orthogneiss	Dog_bn	Highly deformed muscovite-biotite granite/granodiorite orthogneiss; rare sillimanite; lacks garnet	Bonar orthogneiss northern	18_crystalline
Basement (Western Province) igneous rocks	orthogneiss	Dog_bs	Highly deformed garnet-biotite granitoid orthogneiss; 2-4mm feldspar phenocrysts; accessory sillimanite and muscovite	Bonar orthogneiss southern	18_crystalline
Basement (Western Province) igneous rocks	mylonite	Dog_bsm	Mylonitised garnet-biotite granitoid orthogneiss	Mylonitic Bonar orthogneiss	18_crystalline
Basement (Western Province) igneous rocks	granodiorite	Dpg	equigranular, medium grained, biotite granodiorite cut by muscovite-bearing leucogranite pegmatite	Paringa granodiorite	18_crystalline
Basement (Median Batholith) igneous rocks	gabbro	Dr	Undifferentiated gabbro diorite and ultramafic intrusive rocks	Riwaka Complex	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Median Batholith) igneous rocks	diorite	Drb	Two pyroxene biotite diorite amphibolite hornblende-quartz diorite	Devonian intrusions	18_crystalline
Basement (Median Batholith) igneous rocks	gabbro	Drc	Olivine gabbro norite pyroxenite hornblende gabbro and amphibolite	Devonian intrusions	18_crystalline
Basement (Median Batholith) igneous rocks	clinopyroxenite	Drp	Olivine clinopyroxenite bioitite-hornblende pyroxeniteolivine-spinel peridotite hornblende peridotite and dunite	Devonian intrusions	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	Dwg	Massive to weakly foliated, equigranular biotite±muscovite granodiorite, tonalite and granite	granodiorite	18_crystalline
Paleogene sedimentary rocks	limestone	EOj	Stylolitic micritic limestone and calcareous mudstone; highly sheared, occurs as allochthons and olistoliths within Tititira Fmn	limestone	15_undifSed
Paleogene sedimentary rocks	sandstone	EOlb	Basal conglomerate overlain by sst & carb mst, then by granitic breccia, channelised sst with mst clasts overlain by graded sst	sandstone	15_undifSed
Paleogene sedimentary rocks	limestone	EOlbc	Thin bedded, fine grained, nannofossil limestone or marl with minor intercalated channel sandstone beds (graded) and rare chert	limestone	15_undifSed
Paleogene sedimentary rocks	mudstone	EOlbf	Dark brown, massive, carbonaceous mudstone (siltstone) with minor sandstone; conglomerate near top; locally contains concretions	mudstone	15_undifSed
Paleogene sedimentary rocks	breccia	EOlbg	Submarine landslide deposit made of bouldery breccia in a marly to coarse sandy matrix;clasts are locally derived basement rocks	breccia	15_undifSed
Paleogene sedimentary rocks	sandstone	EOlbm	Basal conglomerate and pebbly sandstone overlain by sandstone with carbonaceous mudstone and rare coal	sandstone	15_undifSed
Paleogene sedimentary rocks	sandstone	EOlh	Trough cross-bedded to massive, fine to pebbly sandstone; sandy pebble conglomerate; minor carbonaceous siltstone and coal	sandstone	15_undifSed
Paleogene sedimentary rocks	conglomerate	EOlhc	m-bedded to massive, sandy pebble to boulder conglomerate; minor sandstone. Trough cross-bedding common	conglomerate	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Paleogene sedimentary rocks	conglomerate	EOlhc	m-bedded to massive, sandy pebble to boulder conglomerate; minor sandstone	conglomerate	15_undifSed
Paleogene sedimentary rocks	limestone	EOlhl	dm-bedded and cross-bedded sandy to pebbly limestone, calcareous sandstone, & pebbly sandstone; minor congl & carbonaceous mst	limestone	15_undifSed
Paleogene sedimentary rocks	limestone	EOlo	Bryozoan grain-supported calcarenite with volcanigenic and marly layers		15_undifSed
Paleogene sedimentary rocks	sandstone	EOlwh	sandstone with subordinate conglomerate and carbonaceous mudstone	sandstone	15_undifSed
Paleogene sedimentary rocks	sandstone	EOlwh	sandstone with subordinate conglomerate and carbonaceous mudstone; thin coal seams in Iris Burn	sandstone	15_undifSed
Paleogene sedimentary rocks	conglomerate	EOlwhc	Coarse thick conglomerate with subordinate breccia and sandstone; clasts are mostly granite	conglomerate	15_undifSed
Paleogene sedimentary rocks	conglomerate	EOlwhc	Coarse thick conglomerate with subordinate breccia and sandstone; gabbroic clasts predominate north of Lake Manapouri	conglomerate	15_undifSed
Paleogene sedimentary rocks	sandstone	Ea	Coarse sandstone; conglomerate & minor carbonaceous mudstone; rare coal & breccia. Occurs as fault slivers	sandstone	15_undifSed
Allochthonous rocks	coal	Ea	Carbonaceous mudstone, quartz pebble conglomerate and a sub-bituminous coal seam.		15_undifSed
Paleogene sedimentary rocks	sandstone	Eaa	Quartzofeldspathic cross-bedded sandstone with minor conglomerate; fines upward with carbonaceous mudstone and rare coal at top.	sandstone	15_undifSed
Paleogene sedimentary rocks	sandstone	Eas	Massive to graded or crossbedded lithic sandstone; minor fossiliferous mudstone and olistostromes of breccia-conglomerate	sandstone	15_undifSed
Paleogene sedimentary rocks	conglomerate	Easc	massive basal conglomerate and minor breccia infilling paleovalleys, minor sandstone interbeds	conglomerate	15_undifSed
Paleogene sedimentary rocks	conglomerate	Easc	Massive basal conglomerate and minor breccia infilling paleovalleys; minor sandstone interbeds	conglomerate	15_undifSed
Paleogene sedimentary rocks	sandstone	Eb	Quartz sandstone and conglomerate carbonaceous shale and coal seams	Brunner Coal Measures	15_undifSed
Paleogene sedimentary rocks	sandstone	Eb	Quartz sandstone; conglomerate and carbonaceous shale with lensoid coal seams	Brunner Coal Measures	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Paleogene sedimentary rocks	sandstone	Eb	Quartz sandstone and conglomerate carbonaceous shale and coal seams	Cover	15_undifSed
Paleogene sedimentary rocks	conglomerate	Eb	conglomerate with coal seams up to 4 m thick	Brunner Coal Measures	15_undifSed
Paleogene sedimentary rocks	sandstone	Ee	Pale grey, soft, fine-med quartzose sandstone (Homebush Sandstone); minor greensand at top (Feary Greensand)	Homebush Sandstone	15_undifSed
Paleogene sedimentary rocks	sandstone	Ee	Pale grey, soft, fine-med quartzose sandstone (Homebush Sandstone)	Homebush Sandstone	15_undifSed
Paleogene sedimentary rocks	sandstone	Ee	shallow marine to outer shelf micaceous and glauconitic sandstone; siltstone; and mudstone		15_undifSed
Paleogene sedimentary rocks	sandstone	Ee	Micaceous quartz sandstone/mudstone; pebbly shelly concretionary beds; glauconitic sandstone/mudstone; marl & impure limestone	Eocene marine sediment	15_undifSed
Paleogene sedimentary rocks	sandstone	Ee	Pale grey, soft, fine-med quartzose sandstone (Homebush Sandstone); minor Waipara Greensand near Waianiwaniwa River	Homebush Sandstone	15_undifSed
Neogene sedimentary rocks	sandstone	Ee-eMk	Poorly exposed; deformed Tertiary sediments near Maori Lakes; South Ashburton catchment	Eocene + Miocene sed	15_undifSed
Paleogene sedimentary rocks	mudstone	Ee_b	Light-coloured fine-grained calcareous glauconitic mudstone	Eocene mudstone	15_undifSed
Paleogene sedimentary rocks	sandstone	Ee_h	Green to yellow glauconitic quartz sandstone; minor silt beds and quartz pebble and grit horizons	Eocene sandstone	15_undifSed
Paleogene sedimentary rocks	claystone	Ee_t	Carbonaceous claystone; fossiliferous siltstone; calcareous cemented conglomeratic sandstone	Eocene coal measures	15_undifSed
Paleogene sedimentary rocks	sandstone	Ee_w	Greenish-grey silty very fine glauconitic quartz sandstone	Eocene sandstone	15_undifSed
Paleogene sedimentary rocks	mudstone	Eea	Greenish-grey, sandy glauconitic mudstone; grades laterally north and west into shallow to mid-water sandstone	Eyre Group	15_undifSed
Paleogene sedimentary rocks	sandstone	Eeb	Non-marine quartz sand and conglomerate with clay matrix; lignite seams and carbonaceous mudstone; limonite and silica cemented;		15_undifSed
Paleogene sedimentary rocks	sandstone	Eeb+Ee	Non-marine to shallow marine to outer shelf deposits		15_undifSed

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Paleogene igneous rocks	basalt	Eee	Thin basalt flows and glauconitic greensand	Eyre Group	18_crystalline
Paleogene igneous rocks	basalt	Eev	Interbedded basalt lava flows; pillow lavas; marine tuff; mudstone; sandstone; limestone; rare volcanogenic breccia	View Hill Volcanics	18_crystalline
Paleogene igneous rocks	basalt	Eev	Interbedded basalt lava flows, pillow lavas, marine tuff, mudstone, sandstone, limestone, rare volcanogenic breccia	View Hill Volcanics	18_crystalline
Paleogene igneous rocks	dolerite	Eev	Mainly consisting of a large dolerite sill (Speight 1928) and many dikes; quartzose sandstone xenoliths	View Hill Volcanics	18_crystalline
Allochthonous rocks	mudstone	Egw	Mudstone, minor greensand, red/green mudstone.		15_undifSed
Paleogene sedimentary rocks	mudstone	Egw	Mudstone, minor greensand, red/green mudstone.		15_undifSed
Paleogene sedimentary rocks	claystone	Egw	smectitic, soft to moderately hard claystone, greensand, sandstone and marl	bentonite	15_undifSed
Allochthonous rocks	none	Egw+Ogw	Mudstone, limestone, sandstone		15_undifSed
Paleogene - Neogene sedimentary rocks	none	Egw+Ogw	Mudstone, limestone, sandstone		15_undifSed
Paleogene - Neogene sedimentary rocks	mudstone	Egw+Ogw	smectitic greenish-grey or reddish mudstone, calcareous mudstone, sandy mudstone	undifferentiated Wanstead and W*	15_undifSed
Allochthonous rocks	limestone	Egw+Ogwl	Smectitic mudstone, thin glauconitic beds, minor conglomerate and pebbly mudstone, and calcareous mudstone and muddy limestone.		15_undifSed
Paleogene - Neogene sedimentary rocks	none	Egw+Ogws	Mudstone, limestone, sandstone		15_undifSed
Paleogene - Neogene sedimentary rocks	none	Egw+Ogw~	Mudstone, limestone, sandstone		15_undifSed
Paleogene sedimentary rocks	sandstone	Egwg	Glauconitic sandstone (greensand)		15_undifSed
Allochthonous rocks	sandstone	Egwg	Glauconitic sandstone (greensand)		15_undifSed
Allochthonous rocks	mudstone	Egw~	smectitic calcareous mudstone		15_undifSed
Paleogene sedimentary rocks	sandstone	Ej	Marine sandstone siltstone and limestone lenses of conglomerate and thin coal seams	Cover	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Paleogene sedimentary rocks	mudstone	Elm	mudstone and carbonaceous mudstone with lignite seams	mudstone	15_undifSed
Paleogene igneous rocks	basalt	Elw	Tholeiitic alkalic tuff; agglomerate; basaltic dikes sills and pillow lava		18_crystalline
Paleogene sedimentary rocks	diatomite	Elwd	Calcareous and siliceous massive diatomite with tuff interbeds		15_undifSed
Paleogene sedimentary rocks	tuff	Elwp	Volcanic breccia; agglomerate; tuff and tuff-derived mudstone with richly fossiliferous horizons (Lorne and Upper Pyroclastics)		15_undifSed
Paleogene igneous rocks	olivine basalt	Elws	Olivine tholeiite sill of Waiareka Volcanics		18_crystalline
Paleogene sedimentary rocks	mudstone	Em	Quartzofeldspathic sandstone overlain by carbonaceous mudstone and siltstone with minor conglomerate and thin coal seams.	Maruia Formation	15_undifSed
Paleogene sedimentary rocks	mudstone	Em	Mudstone and quartzofeldspathic sandstone with minor conglomerate and thin coal seams	Maruia Formation	15_undifSed
Neogene sedimentary rocks	sandstone	Em	sandstone and carbonaceous mudstone with minor lignite	sandstone	15_undifSed
Paleogene sedimentary rocks	conglomerate	Em	Conglomerate quartzofeldspathic sandstone carbonaceous mudstone and siltstone thin coal beds	Cover	15_undifSed
Allochthonous rocks	sandstone	Emo	Well bedded, moderately indurated, calcite-cemented, green to grey glauconitic sandstones, with intercalated blue-grey mudstones	Motatau Group	15_undifSed
Allochthonous rocks	sandstone	Emo	Calcite-cemented glauconitic sandstone.		15_undifSed
Allochthonous rocks	mudstone	Emt	Grey to blue-grey, calcareous mudstone, commonly with redeposited glauconitic sandstone beds.		15_undifSed
Allochthonous rocks	mudstone	Emt	Weakly to moderately indurated grey to blue-grey calcareous mudstone commonly with redeposited beds of glauconitic sandstone.	Motatau Group	15_undifSed
Neogene sedimentary rocks	sandstone	En	sandstone and carbonaceous mudstone with minor lignite	sandstone	15_undifSed
Paleogene sedimentary rocks	sandstone	En	Conglomerate and quartzofeldspathic, commonly cross-bedded, sandstone; subordinate carbonaceous mudstone; rare coal	sandstone	15_undifSed

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Paleogene sedimentary rocks	sandstone	Enb	sandstone with minor conglomerate; mudstone; coal and oil shale	coal measures	15_undifSed
Paleogene sedimentary rocks	mudstone	Eno	carbonaceous mudstone to siltstone with rare sandstone beds	mudstone	15_undifSed
Paleogene sedimentary rocks	sandstone	Eoh	Non-marine kaolinitic clay; quartz sandstone and conglomerate; mudstone and lignite		15_undifSed
Paleogene sedimentary rocks	siltstone	Er	Moderately hard brown-grey calcareous siltstone underlain by calcareous granite/Greenland Group conglomerate	Eocene Mikonui sediment	15_undifSed
Paleogene sedimentary rocks	mudstone	Erk	Brown carbonaceous mudstone; locally containing conglomeratic debris-flow beds	Kaiata Formation	15_undifSed
Paleogene sedimentary rocks	mudstone	Erk	Massive mudstone and muddy sandstone	Cover	15_undifSed
Paleogene sedimentary rocks	sandstone	Ers	Shallow marine sand and sandstone		15_undifSed
Paleogene sedimentary rocks	breccia	Es	M-bedded to massive, red weathering, sandy pebble to boulder breccia and breccia-conglomerate. Rare sandstone interbeds	breccia	15_undifSed
Paleogene sedimentary rocks	mudstone	Etk	Carbonaceous mudstone, sandstone, quartz pebble conglomerate and coal seams.		15_undifSed
Allochthonous rocks	mudstone	Etm	Massive to poorly stratified, calcareous, blue-grey mudstone.		15_undifSed
Paleogene sedimentary rocks	mudstone	Etm	Massive blue-grey calcareous mudstone.		15_undifSed
Paleogene sedimentary rocks	mudstone	Etm	Massive to poorly stratified, calcareous, blue-grey mudstone.		15_undifSed
Paleogene sedimentary rocks	sandstone	Etr	Poorly bedded, fossiliferous, dark green, calcareous glauconitic sandstone.		15_undifSed
Paleogene sedimentary rocks	sandstone	Etr	Slightly calcareous, glauconitic, muddy, fine-grained sandstone.		15_undifSed
Allochthonous rocks	sandstone	Etr	Slightly calcareous, glauconitic, muddy, fine-grained sandstone.		15_undifSed
Paleogene sedimentary rocks	mudstone	Etw	Carbonaceous mudstone and claystone with coal seams, minor sandstone and rare conglomerate.		15_undifSed

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Paleogene sedimentary rocks	mudstone	Etw	Carbonaceous mudstone with muddy quartzose sandstone, carbonaceous shale, coal seams and rare conglomerates; siderite concretion		15_undifSed
Paleogene sedimentary rocks	limestone	Eza	Pale, creamy, hard, siliceous, micritic limestone locally interbedded with siltstone, marl, sandstone, chert or greensand; local	Amuri Formation	15_undifSed
Paleogene sedimentary rocks	sandstone	EzaOlnw	Undifferentiated sedimentary and volcanic rocks	undifferentiated Paleocene-Eocen	15_undifSed
Paleogene sedimentary rocks	limestone	Eza_	Pale, creamy, hard, siliceous, micritic limestone locally interbedded with siltstone, marl, sandstone, chert or greensand; local	undifferentiated Eocene	15_undifSed
Paleogene igneous rocks	basalt	Ezg	Intrusive and extrusive igneous rocks, including dikes, flows, sills, pillow lavas and agglomerate of peridotite, gabbro, doleri	Grasseed Volcanics	18_crystalline
Paleogene igneous rocks	basalt	Ezg_	Intrusive and extrusive igneous rocks, including dikes, flows, sills, pillow lavas and agglomerate of peridotite, gabbro, doleri	undifferentiated Eocene	18_crystalline
Basement (Median Batholith) igneous rocks	quartz diorite	JKdi	Undifferentiated, massive to strongly foliated, quartz diorite, diorite, tonalite, granodiorite, granite and quartz monzonite	diorite	18_crystalline
Basement (Median Batholith) igneous rocks	quartz diorite	JKdi	Undifferentiated, massive to gneissic hornblende quartz diorite; enclaves of amphibolite and metasediment	diorite	18_crystalline
Basement (Median Batholith) igneous rocks	gabbro	JKdi	Undifferentiated, coarse grained gabbro with minor amounts of granite	gabbro	18_crystalline
Basement (Median Batholith) igneous rocks	andesite	Jab	Andesite and andesitic breccia.	Big Bush Andesite	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	Jac	Hornblende granodiorite tonalite and quartz diorite widespread metasomatism	Cable Granodiorite	18_crystalline
Basement (Median Batholith) igneous rocks	andesite	Jah	Andesite and diorite with thin dikes and numerous xenoliths		18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Median Batholith) igneous rocks	gabbronorite	Jao	Diorite, tonalite and hornblende gabbronorite.	One Mile Gabbronorite	18_crystalline
Basement (Median Batholith) igneous rocks	andesite	Jap	Hornblende and quartz-biotite andesite	Palisade Andesite	18_crystalline
Basement (Median Batholith) igneous rocks	gabbro	Jas	Altered gabbro and minor pyroxenite.	Seventeen Gabbro	18_crystalline
Basement (Eastern Province) sedimentary rocks	sandstone	Jb	Indurated massive grey medium sandstone with subordinate siltstone and polymict pebble conglomerate; rare belemnites	Barrier Formation	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Jb	Indurated massive grey sandstone with subordinate siltstone and polymict pebble conglomerate, rare belemnites	sandstone	15_undifSed
Basement (Eastern Province) sedimentary rocks	conglomerate	Jbc	sandstone and conglomerate with minor tuff mudstone and coal	conglomerate	15_undifSed
Basement (Median Batholith) igneous rocks	tonalite	Jchg	Pale, fine (in the south) to coarse (in the north), variably foliated biotite tonalite and granodiorite with minor granite	tonalite	18_crystalline
Basement (Western Province) sedimentary rocks	breccia	Jdb	Altered tuff and breccia extensively faulted	Botanical Hill Formation	15_undifSed
Basement (Median Batholith) igneous rocks	diorite	Jddlo	Biotite-hornblende diorite	Darran Suite diorite	18_crystalline
Basement (Median Batholith) igneous rocks	epidiorite	Jdh	Dark green, coarse grained epidiorite, lesser gabbro, and troctolite with pegmatite dikes. Secondary epidote is abundant.	gabbro	18_crystalline
Basement (Median Batholith) igneous rocks	gabbro	Jdh	Weakly foliated to massive, medium-coarse grained hornblende gabbros, sheets&dikes of granite & tonalite, few metased xenoliths	gabbro	18_crystalline
Basement (Western Province) sedimentary rocks	sandstone	Jdm	Breccia sandstone and siltstone with sparse plant fossils	Marybank Formation	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Western Province) sedimentary rocks	conglomerate	Jer	Poorly sorted conglomerate, bedded sandstone and siltstone.	Rainy River Conglomerate	15_undifSed
Basement (Median Batholith) igneous rocks	diorite	Jhib	Variably retrogressed and deformed dark grey-green pyroxene-andesine metadiorite; cut by meta-diorite and meta-granite dikes	gabbro	18_crystalline
Basement (Median Batholith) igneous rocks	diorite	Jhid	Heterogeneous, variably foliated, m to km scale bodies of diorite, qtz diorite & qtz monzodiorite; subord gabbro & granitoids	Hunter diorite	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	Jhig	Stongly foliated, commonly lineated & gneissic, biotite±hornblende tonalite, granodiorite and granite with minor dioritic rocks	Hunter granodiorite	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	Jhig	Variably foliated, commonly lineated, biotite±hornblende tonalite, granodiorite and granite with minor dioritic rocks	Hunter granodiorite	18_crystalline
Basement (Median Batholith) igneous rocks	cataclasite	Jhix	Variably altered and crushed diorite and granodiorite (cataclasite) in major Cenozoic fault zone	cataclasite	18_crystalline
Basement (Median Batholith) igneous rocks	gabbronorite	Jhpg	Undeformed, layered leuco- and melanocratic gabbronorite; minor pyroxenite, dunite, & microdiorite. Intruded by a range of dikes	gabbro	18_crystalline
Basement (Eastern Province) sedimentary rocks	siltstone	Jk	Predominantly massive siltstone with minor tuff, carbonaceous sandstone and conglomerate.		15_undifSed
Basement (Eastern Province) sedimentary rocks	siltstone	Jk	Predominantly massive siltstone with common, thin tuff beds. Interbedded sandstone near top and base: rare grit and conglomerate		15_undifSed
Basement (Western Province) igneous rocks	basalt	Jkd	Clinopyroxene-orthopyroxene basalt and dolerite	Kirwans Dolerite	18_crystalline
Basement (Median Batholith) metamorphic rocks	metavolcanics	Jlb	Massive, grey to green, fine-grained, porphyritic acidic volcanics	metavolcanics	18_crystalline
Basement (Median Batholith) metamorphic rocks	metavolcanics	Jlb	Quartz-muscovite schist; red, green, & grey schistose mudstone; massive hematised & saussuritised lava; pillow breccia	metavolcanics	18_crystalline

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Basement (Median Batholith) metamorphic rocks	metavolcanics	Jlb	Variably schistose andesitic, dacitic & rhyolitic lava flows & dikes, tuff, ignimbrite, volcaniclastic sst & congl; minor mst	metavolcanics	18_crystalline
Basement (Median Batholith) metamorphic rocks	metaconglomerate	Jlbc	Metaconglomerate with mainly granitoid clasts, interbedded with subordinate, variably schistose sandstone, mudstone & metatuff	metaconglomerate	18_crystalline
Basement (Median Batholith) metamorphic rocks	metaconglomerate	Jlbc	Metaconglomerate with mainly volcanic clasts, interbedded with subordinate, variably schistose sandstone, mudstone & metatuff	metaconglomerate	18_crystalline
Basement (Eastern Province) sedimentary rocks	sandstone	Jm	massive fine to medium sandstone with interbedded thin argillite; some alternating sandstone and argillite.		15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Jm	Massive fine to medium sandstone with interbedded siltstone, argillite and conglomerate.		15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Jm	Massive fine to medium sandstone with interbedded thin argillite; some alternating sandstone and argillite.		15_undifSed
Basement (Eastern Province) sedimentary rocks	conglomerate	Jma	Coarse, feldspathic and lithic volcanic allochthonous conglomerate and sandstone, with minor bedded siltstone/mudstone.		15_undifSed
Basement (Median Batholith) igneous rocks	quartz diorite	Jmi	Heterogeneous m to km scale bodies of massive quartz diorite & tonalite with subordinate gabbro, diorite, granodiorite & granite	quartz diorite	18_crystalline
Basement (Median Batholith) igneous rocks	gabbro	Jmib	Massive hornblende gabbro with subordinate diorite	gabbro	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	Jmig	Biotite granodiorite, tonalite, and granite	granodiorite	18_crystalline
Basement (Eastern Province) sedimentary rocks	sandstone	Jmt	Interbedded feldspar-lithic volcanic sandstone, siltstone and mudstone/argillite, with minor conglome		15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Jmt	Interbedded feldspar-lithic volcanic sandstone, siltstone and mudstone/argillite, with minor conglomerate and coarse sandstone.		15_undifSed

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Basement (Eastern Province) sedimentary rocks	siltstone	Jn	Predominantly fossiliferous siltstone with minor sandstone, conglomerate and shell beds.	Newcastle Group (Early Jurassic)	15_undifSed
Basement (Eastern Province) sedimentary rocks	siltstone	Jn	Predominantly siltstone with minor sandstone and shell beds. Well-bedded sandstone and siltstone, and minor conglomerate in low		15_undifSed
Basement (Median Batholith) igneous rocks	gabbro	Jpi	undifferentiated olivine and hornblende gabbro with troctolite; peridotite and anorthosite	gabbro	18_crystalline
Basement (Median Batholith) igneous rocks	quartz diorite	Jpib	quartz diorite with hybrid contact zones	diorite	18_crystalline
Basement (Median Batholith) igneous rocks	granite	Jpig	medium grained biotite granite	granite	18_crystalline
Basement (Median Batholith) igneous rocks	granite	Jr	Altered sheared biotite granite and granodiorite and amphibolitic hornblende biotite diorite	Jurassic intrusions	18_crystalline
Basement (Median Batholith) igneous rocks	diorite	Jra	Migmatitic mafic to leucocratic diorite, quartz diorite, microdiorite and trondjhemite.	Braeburn Diorite	18_crystalline
Basement (Median Batholith) igneous rocks	migmatite	Jram	Gneissic mafic to leucocratic diorite, quartz diorite, microdiorite and trondjhemite, locally migmatitic.	Braeburn Diorite	18_crystalline
Basement (Eastern Province) sedimentary rocks	sandstone	Jrb	Grey, poorly sandstone and siltstone with conglomerate and carbonaceous horizons.	Berneyboosal Formation	15_undifSed
Basement (Median Batholith) igneous rocks	gabbro	Jrh	Layered gabbro, gabbronorite, hornblende gabbro, and norite.	Howard Gabbro	18_crystalline
Basement (Median Batholith) metamorphic rocks	amphibolite	Jrk	Lenses and dikes of amphibolite and metadolerite, commonly sheared and schistose.	Kawatiri Amphibolite	18_crystalline
Basement (Eastern Province) sedimentary rocks	conglomerate	Jt1_cc	Conglomerate of well rounded greywacke pebbles/boulders and granodiorite pebbles; interbedded with plant bearing strata	Clent Hills conglomerate	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Eastern Province) sedimentary rocks	sandstone	Jt1_ch	Bedded sandstone siltstone; conglomerate lenses; red/green laminated siltstone; zeolite-veined sandstone. Plant fossils common	Clent Hills greywacke	15_undifSed
Basement (Eastern Province) sedimentary rocks	siltstone	Jt1_cs	Thin-bedded siltstone-dominated units; minor sandstone channels (80:20); commonly disrupted/folded	Clent Hills siltstone-argillite	15_undifSed
Basement (Eastern Province) sedimentary rocks	conglomerate	Jt1w	Thick conglomerate with gwke & rare granite clasts; Sst & carbonaceous mst beds with abundant plant fossils; thin coal lenses	Wakaepa Formation	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Jtk	massive sandstone to alternating sandstone and argillite and broken formation	greywacke	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Jtk	massive sandstone to alternating sandstone and argillite and melange		15_undifSed
Basement (Eastern Province) metamorphic rocks	schist	Jtk_	Localised zones of schistose and non-schistose rocks	schist	18_crystalline
Basement (Eastern Province) igneous rocks	diorite	Jtpd	Small stock of biotite-hornblende-augite microdiorite intruding Rakaia terrane	Pember Diorite	18_crystalline
Basement (Median Batholith) igneous rocks	anorthosite	Jwka	Unfoliated, leucocratic anorthositic olivine gabbro and minor troctolite. Forms core of West Kepler Gabbro intrusion	anorthosite	18_crystalline
Basement (Median Batholith) igneous rocks	gabbro	Jwkg	Unfoliated, pyroxene-hornblende gabbro and hornblende gabbro	gabbro	18_crystalline
Paleogene sedimentary rocks	sandstone	KEom(e)	shallow marine to outer shelf micaceous and glauconitic sandstone; siltstone; and mudstone		15_undifSed
Late Cretaceous - Paleogene sedimentary rocks	sandstone	KEot(e)	Non-marine quartz sand and conglomerate with clay matrix; lignite seams and carbonaceous mudstone; limonite and silica cemented;		15_undifSed
Late Cretaceous - Paleogene sedimentary rocks	sandstone	KEot(k)	Non-marine quartz sand and conglomerate with clay matrix; lignite seams and carbonaceous mudstone; limonite and silica cemented		15_undifSed

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Allochthonous rocks	melange	KOm	Melange, comprising a matrix of sheared mudstone with included tectonic blocks of Northland Allochthon, Te Kuiti Group and Wait	Undifferentiated melange	15_undifSed
Allochthonous rocks	melange	KOm	Melange, comprising a matrix of sheared mudstone with included tectonic blocks of Northland Allochthon, Te Kuiti Group and Wait		15_undifSed
Paleogene sedimentary rocks	sandstone	KOom(e)	shallow marine to outer shelf micaceous and glauconitic sandstone; siltstone; and mudstone		15_undifSed
Paleogene sedimentary rocks	sandstone	KOom(eo)	deepening facies sequence from shallow marine glauconitic sandstone; siltstone; marl; to biopelagic chalk		15_undifSed
Late Cretaceous - Paleogene sedimentary rocks	sandstone	KOom(kp)	shallow marine to outer shelf micaceous and glauconitic sandstone; siltstone; and mudstone		15_undifSed
Basement (Median Batholith) metamorphic rocks	orthogneiss	Kam	Coarsely foliated & layered gabbroic, dioritic & quartz dioritic orthogneiss. Rafts of Paleozoic metasediment and granitic rocks	orthogneiss	18_crystalline
Basement (Eastern Province) sedimentary rocks	sandstone	Kam	Well bedded; commonly graded; sandstone and siltstone with minor spilitic volcanics		15_undifSed
Basement (Eastern Province) sedimentary rocks	conglomerate	Kam	Conglomerate, sandstone and alternating sandstone and mudstone	greywacke	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Kam	highly deformed alternating sandstone and mudstone	greywacke	15_undifSed
Basement (Eastern Province) sedimentary rocks	basalt	Kamv	weathered basalt, red and green argillite	volcanics Kopi Boninite	15_undifSed
Basement (Eastern Province) sedimentary rocks	basalt	Kamv	Spilitic volcanics		15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Kat	Sandstone dominated lenses		15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Eastern Province) sedimentary rocks	sandstone	Kat	massive sandstone	massive sandstone	15_undifSed
Early Cretaceous igneous rocks	basalt	Kav	Basalt,limestone, chert	volcanics at Red Island and Hin*	18_crystalline
Late Cretaceous sedimentary rocks	sandstone	Kb	well bedded alternating sandstone, mudstone and argillite	Cretaceous cover sequence	15_undifSed
Late Cretaceous sedimentary rocks	sandstone	Kb	Well-bedded, alternating sandstone, mudstone and conglomerate		15_undifSed
Late Cretaceous igneous rocks	basalt	Kbv	sills		18_crystalline
Cretaceous igneous rocks	granite	Kc	Biotite-hornblende granite with porphyritic Kfeldspar	Cretaceous intrusions	18_crystalline
Basement (Median Batholith) igneous rocks	anorthosite	Kda	Olivine bearing anorthosite, troctolite and peridotite; primary igneous layering in places	gabbro	18_crystalline
Basement (Median Batholith) igneous rocks	tonalite	Kdat	Variably foliated, fine-medium grained, equigranular tonalite. Widespread alteration and local sulphide mineralisation in shears	tonalite	18_crystalline
Basement (Median Batholith) igneous rocks	gabbronorite	Kdd	Variably deformed biotite leucogabbronorite altered to hornblende diorite in west; trondhjemite, pegmatite &quartz diorite dikes	gabbro	18_crystalline
Basement (Median Batholith) igneous rocks	microdiorite	Kdg	Fine grained diorite & quartz diorite with minor gabbronorite & granite; mafic dikes; andesitic inclusions; trondhjemitic gneiss	diorite	18_crystalline
Basement (Karamea Batholith) igneous rocks	granite	Kdgro	White coarse-grained biotite granite	Darran Suite granite	18_crystalline
Basement (Median Batholith) igneous rocks	quartz monzonite	Kdl	Massive to weakly deformed porphyritic epidote-biotite granite to porphyritic quartz monzonite with numerous dioritic enclaves	granite	18_crystalline
Basement (Median Batholith) igneous rocks	diorite	Kdn	Intrusive breccias of leucogranite into diorite with volcanic xenoliths and rafts; partly foliated	diorite	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Cretaceous igneous rocks	breccia	Ke	Lamprophric intrusion breccia and dikes with Greenland Group inclusions/clasts	lamprophyre	18_crystalline
Basement (Median Batholith) igneous rocks	cataclasite	KeCabpz	zone of cataclasis (cataclasite rock) overprinting Big Pluton granite and granodiorite	granite	18_crystalline
Cretaceous sedimentary rocks	conglomerate	Ke_w	Conglomerate/breccia of Torlesse sandstone and siltstone clasts; pebbly mudstone; sandstone containing fish fossils	Cretaceous lithic conglomerate	15_undifSed
Cretaceous sedimentary rocks	conglomerate	Keh	Terrestrial conglomerate of schist greywacke and quartz in angular sand matrix; coal layers		15_undifSed
Cretaceous sedimentary rocks	conglomerate	Kek	Terrestrial breccia and conglomerate of greywacke and schist with some carbonaceous and calcareous layers; and minor acid tuff l		15_undifSed
Late Cretaceous sedimentary rocks	conglomerate	Kem	Conglomerate with rhyolite & greywacke clasts, carbonaceous and pebbly sst & mst, minor coal lenses; fines up section	Monro Conglomerate	15_undifSed
Basement (Eastern Province) melange	sandstone	Kep	Sandstone blocks and packets of thin-bedded sandstone and mudstone in a sheared mudstone matrix		15_undifSed
Basement (Eastern Province) melange	broken formation	Kew	broken formation and melange	melange	15_undifSed
Basement (Hohonu Batholith) igneous rocks	granite	Kfgfg	Red syenogranite	French Creek Granite	18_crystalline
Late Cretaceous sedimentary rocks	sandstone	Kg	Grey graded sandstone and siltstone; minor siltstone and conglomeratic interbeds		15_undifSed
Basement (Median Batholith) metamorphic rocks	paragneiss	Kgdc	Garnet-biotite-sillimanite-kyanite paragneiss.	Glenroy Complex	18_crystalline
Basement (Median Batholith) igneous rocks	granite	Kgwg	Hornblende-biotite granite with minor two-pyroxene dioritic granulite.	Glenroy Complex	18_crystalline
Early Cretaceous sedimentary rocks	conglomerate	Kh	Conglomerate red stained and crushed against the Waimea-Flaxmore Faults	Cover	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Eastern Province) sedimentary rocks	sandstone	Kh	Undifferentiated Rangiawhia volcanics and Tokerau facies.		15_undifSed
Basement (Eastern Province) igneous rocks	granitoid	Khg	Stocks or a small pluton of granopphyre, locally including partly assimilated Rangiawhia volcanics host rocks.		18_crystalline
Basement (Median Batholith) metamorphic rocks	dioritic orthogneiss	Khg	Tightly folded, banded dioritic, tonalitic, quartz dioritic and minor plagioclase-rich gneisses; cut by many leucocratic dikes	orthogneiss	18_crystalline
Basement (Eastern Province) igneous rocks	granitoid	Khg~	Stocks or a small pluton of granopphyre, locally including partly assimilated Rangiawhia volcanics host rocks.		18_crystalline
Basement (Eastern Province) igneous rocks	basalt	Khr	Pillowed and massive flows of basalt and basaltic andesite, interbedded with rhyolitic tuff and tuff-breccia.		18_crystalline
Basement (Eastern Province) igneous rocks	basalt	Khr~	Pillowed and massive flows of basalt and basaltic andesite, interbedded with rhyolitic tuff and tuff-breccia.		18_crystalline
Basement (Eastern Province) sedimentary rocks	sandstone	Kht	Well bedded sandstone and mudstone, in places as broken formation. Locally includes conglomerate, breccia, and mudstone.		15_undifSed
Basement (Median Batholith) metamorphic rocks	ultramafics	Khu	Gneissic ultramafic bodies within Milford Orthogneiss	ultramafics	18_crystalline
Basement (Eastern Province) sedimentary rocks	sandstone	Kh~	Undifferentiated Rangiawhia volcanics and Tokerau facies.		15_undifSed
Late Cretaceous igneous rocks	basalt	Ki	Undifferentiated mafic igneous rock.	undiff. igneous	18_crystalline
Late Cretaceous sedimentary rocks	sandstone	Kia	Mudstone, glauconitic sandstone and mudstone with minor red mudstone, greensand dikes and concretions		15_undifSed
Late Cretaceous sedimentary rocks	sandstone	Kia	glauconitic sandstone	sandstone	15_undifSed
Early Cretaceous igneous rocks	syenite	Kim	Syenite and gabbro, with minor associated intrusive and volcanic rocks.	Mandamus Igneous Complex	18_crystalline

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Early Cretaceous igneous rocks	pyroxenite	Kit	Layered pyroxenite-peridotite-anorthosite-gabbro-syenite; upper part intruded by syenite sills and dikes.	Tapuaenuku Igneous Complex	18_crystalline
Late Cretaceous sedimentary rocks	sandstone	Kit	Basal conglomerate, poorly bedded quartzose and commonly carbonaceous sandstone		15_undifSed
Late Cretaceous sedimentary rocks	sandstone	Kit	massive to well bedded quartzone sandstone, with minor glauconitic siltstone and limestone		15_undifSed
Late Cretaceous - Paleogene sedimentary rocks	mudstone	Kiw	Hard siliceous, poorly calcareous (lower), calcareous (upper) mudstone or shale.		15_undifSed
Late Cretaceous - Paleogene sedimentary rocks	mudstone	Kiw	Dark brown; siliceous; micaceous mudstone; siltstone; and sandy siltstone; numerous concretions		15_undifSed
Late Cretaceous - Paleogene sedimentary rocks	mudstone	Kiw	siliceous mudstone, glauconitic sandstone, alternating sandstone and mudstone, minor chert lenses, chocolate shale		15_undifSed
Late Cretaceous - Paleogene sedimentary rocks	mudstone	Kiw	hard siliceous, poorly calcareous (lower), calcareous (upper) mudstone or shale.		15_undifSed
Late Cretaceous - Paleogene sedimentary rocks	mudstone	Kiw	rusty weathered mudstone with minor greensand and glauconitic sandstone	chocolate shale	15_undifSed
Allochthonous rocks	mudstone	Kiw	Hard siliceous, poorly calcareous (lower), calcareous (upper) mudstone or shale.		15_undifSed
Late Cretaceous - Neogene sedimentary rocks	mudstone	Kiw+Egw	siliceous mudstone, claystone and sandstone	undifferentiated Tinui and Mang*	15_undifSed
Late Cretaceous - Paleogene sedimentary rocks	mudstone	Kiw-Egw	Noncalcareous mudstone, smectitic mudstone, and thin glauconite beds.		15_undifSed
Allochthonous rocks	mudstone	Kiw-Egw	Noncalcareous mudstone, smectitic mudstone, and thin glauconite beds.		15_undifSed
Allochthonous rocks	mudstone	Kiw-Egw~	Noncalcareous mudstone, smectitic mudstone, and thin glauconite beds.		15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Cretaceous - Paleogene sedimentary rocks	mudstone	Kiw-Ogw	undifferentiated Tinui and Mangatu groups		15_undifSed
Late Cretaceous - Paleogene sedimentary rocks	mudstone	Kiw-Ogw	Noncalcareous mudstone, smectitic mudstone, and thin glauconite beds, and muddy limestone.		15_undifSed
Basement (Median Batholith) mylonite	amphibolite	Kj	Banded and strongly foliated to mylonitic metadioritic (amphibolitic) garnet-bearing gneiss derived from Worsley Pluton	amphibolite	18_crystalline
Basement (Median Batholith) mylonite	amphibolite	Kj	Banded and strongly foliated to mylonitic metadioritic (amphibolitic) garnet-bearing gneiss derived from Milford Orthogneiss	amphibolite	18_crystalline
Allochthonous rocks	mudstone	Kk	Undifferentiated alternating mudstone and sandstone, siliceous mudstone and micritic muddy limestone.		15_undifSed
Allochthonous rocks	mudstone	Kk	Closely fractured to sheared, light or dark coloured, siliceous and sometimes calcareous mudstone, with micaceous sandstone, sil		15_undifSed
Allochthonous rocks	mudstone	Kk	Structurally complex units of tectonically intercalated sandstone and mudstone lithofacies.	Undifferentiated	15_undifSed
Allochthonous rocks	mudstone	Kkh	Red, brown, green and grey, typically noncalcareous, commonly highly sheared mudstone, with small serpentinite bodies.		15_undifSed
Allochthonous rocks	mudstone	Kkh	Soft red, brown, green, yellow and grey mudstone, commonly highly sheared to broken formation or melange.		15_undifSed
Allochthonous rocks	mudstone	Kkh	Thin-bedded red, brown, green and grey mudstone.		15_undifSed
Allochthonous rocks	sandstone	Kkm	Moderately indurated, centimetre- to decimetre-bedded mid to dark grey fine-grained sandstone and blue-grey mudstone.		15_undifSed
Allochthonous rocks	sandstone	Kkp	Weakly indurated metre-bedded quartzose, micaceous sandstone, with minor conglomerate, and interbeds of blue-grey mudstone.		15_undifSed
Allochthonous rocks	sandstone	Kkp	Weakly to moderately indurated, alternating thin- to thick-bedded, quartzofeldspathic sandstone and mudstone.		15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Allochthonous rocks	mudstone	Kkw	Cream to grey, siliceous and sometimes calcareous mudstone to fine sandy siltstone.		15_undifSed
Allochthonous rocks	mudstone	Kkw	Massive to thinly bedded, siliceous mudstone, locally with thin glauconitic sandstone interbeds.		15_undifSed
Allochthonous rocks	mudstone	Kkw	Mudstone.	Undifferentiated mudstone	15_undifSed
Allochthonous rocks	mudstone	Kkw	Fissile, dark grey to white-weathering siliceous mudstone, blue-grey calcareous mudstone, and minor micritic limestone and chert		15_undifSed
Basement (Median Batholith) igneous rocks	andesite	Klb	Massive feldspar-phyric & less common aphyric andesite flows; minor volcaniclastic rocks	volcanics	18_crystalline
Basement (Median Batholith) igneous rocks	andesite	Klm	Massive feldspar-phyric & aphyric andesite with subordinate andesitic breccia; likely to be shallow intrusives rather than flows	volcanics	18_crystalline
Basement (Median Batholith) igneous rocks	pyroclastics	Kln	Felsic pyroclastics & flows of mainly dacitic composition; well bedded felsic tuff; lapilli tuff; breccia; agglomerate; rhyolite	volcanics	18_crystalline
Basement (Median Batholith) igneous rocks	lapilli tuff	Klw	Andesitic to dacitic pyroclastics; volcanic breccia and lapilli tuff; minor tuffaceous sandstone and siltstone; andesitic dikes	volcanics	18_crystalline
Late Cretaceous igneous rocks	andesite	Kma	Basaltic to dacitic andesite flows; slightly porphyritic	Andesite undifferentiated	18_crystalline
Late Cretaceous igneous rocks	andesite	Kma	Dark grey to black, vesicular, plag-& pyroxene phyric andesite lava flows; volcanic breccia; rare tuff	McQueens Andesite	18_crystalline
Late Cretaceous igneous rocks	andesite	Kma_b	Basaltic - dacitic andesite flows; local columnar joints; slightly porphyritic; tuff/scoria interbeds; amygdules of banded agate	Barrosa andesite	18_crystalline
Late Cretaceous igneous rocks	dacite	Kmd_hr	Black glassy and porphyritic dacite flows or dikes; contains garnet-bearing sediment xenoliths; amygdules of banded agate	Hinds River dacite	18_crystalline
Basement (Median Batholith) igneous rocks	granite	Kmg	Massive, medium to coarse grained, locally K-feldspar megacrystic, biotite-muscovite granite and leucogranite	granite	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Cretaceous igneous rocks	ignimbrite	Kmi	Thick sheets of porphyritic and lithic-rich ignimbrite flows (most commonly 2-10m thick). Rare andesitic lava flows or dikes	Rockwood ignimbrite	18_crystalline
Late Cretaceous igneous rocks	ignimbrite	Kmi	Thick sheets of porphyritic and lithic-rich ignimbrite flows; 10cm-30m thick (most commonly 2-10m).	Rockwood ignimbrite	18_crystalline
Late Cretaceous igneous rocks	ignimbrite	Kmi	Ignimbrite sheets; individual sheets 0.1m to 30m thick (most commonly 2m - 10m)	Ignimbrite undifferentiated	18_crystalline
Late Cretaceous igneous rocks	dolerite	Kmo_gc	Basaltic andesitic sills with porphyritic doleritic texture; up to 100m thick; plagioclase hypersthene & pigeonite phenocrysts	Grahams Creek dolerite	18_crystalline
Late Cretaceous igneous rocks	rhyolite	Kmr	Vesicular flow banded rhyolite w minor dacite; flows and domes; minor ignimbrite; localised zst, sst, & carb mst plant beds	Gebbies Rhyolite	18_crystalline
Late Cretaceous igneous rocks	rhyolite	Kmr	Coalescing rhyolite domes with near-vertical flow banding; flows; coulees; minor rhyolite agglomerate	Somers/Alford/Rata Peak rhyolite	18_crystalline
Late Cretaceous igneous rocks	rhyolite	Kmr	Porphyritic rhyolite with steep flow banding; flows; minor rhyolite agglomerate; has dome morphology	Iron Bridge rhyolite	18_crystalline
Late Cretaceous igneous rocks	tuff	Kmt	Semi-welded rhyolitic tuff; coarse ash-flow tuff; silicified flinty tuff; locally carbonaceous sediments; conspicuous garnet	Tuff undifferentiated	18_crystalline
Late Cretaceous - Paleogene sedimentary rocks	sandstone	Kmw	Moderately indurated breccia, conglomerate, sandstone and mudstone unconformably overlain by centimetre-bedded dark grey to blac		15_undifSed
Late Cretaceous - Paleogene sedimentary rocks	sandstone	Kmw~	Moderately indurated breccia, conglomerate, sandstone and mudstone unconformably overlain by centimetre-bedded dark grey to blac		15_undifSed
Basement (Median Batholith) igneous rocks	granodiorite	Knf	Massive, medium-coarse grained, equigranular, biotite granodiorite and subordinate granite; late stage pegmatite dikes	granite	18_crystalline
Early Cretaceous sedimentary rocks	breccia	Kng	matrix supported sedimentary conglomerate with sedimentary and igneous clasts	olistostrome	15_undifSed
Early Cretaceous sedimentary rocks	conglomerate	Kng	matrix supported sedimentary conglomerate	olistostrome	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Early Cretaceous sedimentary rocks	mudstone	Kns	massive concretionary mudstone, alternating sandstone and mudstone, minor conglomerate and tuff		15_undifSed
Early Cretaceous sedimentary rocks	mudstone	Kns	fossiliferous mudstone dominated unit	conglomerate	15_undifSed
Late Cretaceous sedimentary rocks	sandstone	Knu	Poorly sorted basal breccia; conglomerate; and pebbly siltstone to muddy sandstone; grading to alternating sandstone-siltstone		15_undifSed
Allochthonous rocks	gabbro	Kog	gabbro, dolerite, minor diorite and teschenite	ophiolite	18_crystalline
Allochthonous rocks	mudstone	Kos	intercalated sandstone, mudstone, limestone and chert; commonly sheared	ophiolite	15_undifSed
Allochthonous rocks	basalt	Kov	Pillows and dikes of basalt (KPv), gabbro (KPg), minor sedimentary intercalations (KPs).	ophiolite	18_crystalline
Late Cretaceous sedimentary rocks	sandstone	Kpc	Fluvial sandstone; conglomerate and coal seams; locally with thick lacustrine mudstone	Paparoa Coal Measures	05_fluvialEstuarine
Basement (Median Batholith) igneous rocks	granodiorite	Kplp	Medium grained, locally foliated to massive, equigranular biotite granodiorite; grades into minor quartz monzodiorite & granite	granodiorite	18_crystalline
Paleogene sedimentary rocks	sandstone	Kpn	Interbedded sandstone and siltstone with minor conglomerate	Cover	15_undifSed
Late Cretaceous sedimentary rocks	conglomerate	Kpo	Conglomerate containing Paleozoic clasts	Cover	15_undifSed
Late Cretaceous sedimentary rocks	sandstone	Kpp	Interbedded sandstone and siltstone with coal measures	Cover	15_undifSed
Late Cretaceous sedimentary rocks	sandstone	Kpr	Sandstone with interbedded carbonaceous mudstone and thin coal seams	Cover	15_undifSed
Cretaceous sedimentary rocks	conglomerate	Kps	Interbedded pebble/cobble/granule conglomerates, cross stratified sandstone, and carbonacous mudstone with thin coal seams	conglomerate	15_undifSed
Cretaceous sedimentary rocks	sandstone	Kpw	Thick bedded & graded arkosic sandstone and siltstone with subordinate mudstone and rare conglomerate	sandstone	15_undifSed
Basement (Karamea Batholith) igneous rocks	quartz diorite	Krd	Quartz diorite	Cretaceous intrusions	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Karamea Batholith) igneous rocks	granodiorite	Krdto	Hornblende diorite	Rahu Suite diorite	18_crystalline
Basement (Western Province) igneous rocks	granite	Krg	Biotite or muscovite-biotite granite	Rahu Suite granite	18_crystalline
Basement (Karamea Batholith) igneous rocks	granite	Krg	Biotite or muscovite-biotite granite	Rahu Suite granite	18_crystalline
Basement (Paparoa Batholith) igneous rocks	granite	Krg	Biotite or muscovite-biotite granite	Rahu Suite granite	18_crystalline
Basement (Hohonu Batholith) igneous rocks	granite	Krgah	White medium-coarse-grained muscovite-biotite monzogranite with K-feldspar megacrysts	Rahu Suite granite	18_crystalline
Basement (Karamea Batholith) igneous rocks	granite	Krgba	Light medium-grained 2-mica granite; locally garnetiferous	Rahu Suite granite	18_crystalline
Basement (Karamea Batholith) igneous rocks	granite	Krgbd	Medium-grained light pinkish-brown biotite-muscovite granite	Rahu Suite granite	18_crystalline
Basement (Paparoa Batholith) igneous rocks	granite	Krgbl	White medium-grained muscovite-biotite granite	Rahu Suite granite	18_crystalline
Basement (Paparoa Batholith) igneous rocks	granite	Krgbu	White medium-grained biotite-muscovite granite; locally foliated	Rahu Suite granite	18_crystalline
Basement (Karamea Batholith) igneous rocks	granite	Krgdr	White; medium-grained muscovite granite; locally garnetiferous	Rahu Suite granite	18_crystalline
Basement (Karamea Batholith) igneous rocks	granite	Krgmr	White coarse-grained; variably foliated porphyritic biotite granite	Rahu Suite granite	18_crystalline
Basement (Hohonu Batholith) igneous rocks	granite	Krgpp	Orange-brown coarse-grained biotite monzogranite with large K-feldspar megacrysts	Rahu Suite granite	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Hohonu Batholith) igneous rocks	granite	Krgtk	White; coarse-grained biotite-muscovite monzogranite with K-feldspar megacrysts	Rahu Suite granite	18_crystalline
Basement (Karamea Batholith) igneous rocks	granite	Krgwa	Brown-white medium-grained weakly foliated biotite granodiorite	Rahu Suite granite	18_crystalline
Allochthonous rocks	sandstone	Kri	alternating sandstone mudstone		15_undifSed
Basement (Karamea Batholith) igneous rocks	granite	Krm	Leucocratic muscovite granite	Rahu Suite granite	18_crystalline
Basement (Hohonu Batholith) igneous rocks	granodiorite	Krt	Biotite granodiorite or tonalite	Rahu Suite tonalite/granodiorite	18_crystalline
Basement (Karamea Batholith) igneous rocks	granodiorite	Krt	Biotite granodiorite or tonalite	Rahu Suite tonalite/granodiorite	18_crystalline
Basement (Karamea Batholith) igneous rocks	granodiorite	Krtbp	Biotite microgranodiorite	Rahu Suite diorite	18_crystalline
Basement (Western Province) igneous rocks	granodiorite	Krtbp	Biotite microgranodiorite	Rahu Suite diorite	18_crystalline
Basement (Hohonu Batholith) igneous rocks	granodiorite	Krtde	Coarse-grained biotite-hornblende granodiorite with large Kspar megacrysts	Rahu Suite diorite	18_crystalline
Basement (Hohonu Batholith) igneous rocks	granodiorite	Krtjc	Medium-grained biotite granodiorite and granite; few megacrysts of white K-feldspar	Rahu Suite diorite	18_crystalline
Basement (Karamea Batholith) igneous rocks	granodiorite	Krtrp	White medium-grained biotite granodiorite; rare hornblende	Rahu Suite diorite	18_crystalline
Basement (Paparoa Batholith) igneous rocks	diorite	Krtrq	Dark; medium-grained foliated biotite tonalite	Rahu Suite diorite	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Paparoa Batholith) igneous rocks	granodiorite	Krtst	Dark grey coarse-grained biotite granodiorite; weakly foliated	Rahu Suite granite	18_crystalline
Basement (Karamea Batholith) igneous rocks	granodiorite	Krttk	Grey-white fine-medium-grained biotite granodiorite	Rahu Suite diorite	18_crystalline
Basement (Hohonu Batholith) igneous rocks	granodiorite	Krttw	White-green medium-grained sphene-hornblende-biotite granodiorite	Rahu Suite diorite	18_crystalline
Basement (Median Batholith) metamorphic rocks	gabbroic orthogneiss	Ksa	Dioritic & gabbroic orthogneiss in west; weakly foliated gabbro, gabbronorite & minor peridotite in east; many leucocratic dikes	orthogneiss	18_crystalline
Basement (Karamea Batholith) igneous rocks	granodiorite	Ksd	Equigranular hornblende +/- biotite granodiorite	Cretaceous intrusions	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	Ksd	Equigranular hornblende +/- biotite granodiorite	Cretaceous intrusions	18_crystalline
Basement (Western Province) igneous rocks	granodiorite	Ksd	Equigranular hornblende +/- biotite granodiorite	Cretaceous intrusions	18_crystalline
Basement (Karamea Batholith) igneous rocks	granodiorite	Ksdmc	Coarse-grained foliated hornblende-biotite granodiorite with large pink K-feldspar megacrysts	Separation Point Suite diorite	18_crystalline
Basement (Karamea Batholith) igneous rocks	diorite	Ksdmm	Hornblende diorite	Separation Point Suite diorite	18_crystalline
Basement (Karamea Batholith) igneous rocks	granite	Ksg	Biotite or hornblende-biotite granite	Separation Point Suite granite	18_crystalline
Basement (Western Province) igneous rocks	granite	Ksg	Equigranular biotite granite	Cretaceous intrusions	18_crystalline
Basement (Median Batholith) igneous rocks	granite	Ksg	Biotite or hornblende-biotite granite	Separation Point Suite granite	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Karamea Batholith) igneous rocks	granite	Ksg	Equigranular biotite granite	Cretaceous intrusions	18_crystalline
Basement (Median Batholith) igneous rocks	granite	Ksg	Equigranular biotite granite	Cretaceous intrusions	18_crystalline
Basement (Median Batholith) igneous rocks	granite	Ksg	Biotite or hornblende-biotite granite and granodiorite	Separation Point Suite granite	18_crystalline
Basement (Median Batholith) igneous rocks	granite	Ksgd	massive leucocratic syenogranite	granite	18_crystalline
Basement (Median Batholith) igneous rocks	granite	Ksgd	Variably foliated, med-coarse grained, locally K-feldspar megacrystic monzogranite & granodiorite; minor tonalite & qtz diorite	granite	18_crystalline
Basement (Median Batholith) igneous rocks	granite	Ksgd	coarse to very coarse, massive to weakly foliated biotite granite and granodiorite with pegmatite dikes	granite	18_crystalline
Basement (Median Batholith) igneous rocks	tonalite	Ksgd	Massive, medium- to coarse-grained, equigranular tonalite & subordinate granodiorite; minor quartz diorite; metased xenoliths	tonalite	18_crystalline
Basement (Median Batholith) igneous rocks	granite	Ksgd	Fine-medium grained leucocratic biotite granite and granodiorite forming small stocks and plugs; locally grades into pegmatite	granite	18_crystalline
Basement (Karamea Batholith) igneous rocks	granite	Ksgdg	Medium-grained biotite granite	Separation Point Suite granite	18_crystalline
Basement (Karamea Batholith) igneous rocks	granodiorite	Ksgdr	White medium-grained muscovite granite; locally garnetiferous	Separation Point Suite granite	18_crystalline
Basement (Median Batholith) igneous rocks	quartz diorite	Ksi	Sheeted intrusions of leucoquartz diorite, tonalite and granodiorite into older dioritic and minor gabbroic orthogneiss	diorite	18_crystalline
Basement (Karamea Batholith) igneous rocks	monzogranite	Ksm	Biotite quartz monzogranite	Cretaceous intrusions	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Median Batholith) igneous rocks	granite	Ksn	Massive, medium grained, porphyritic biotite granite; minor aplite	granite	18_crystalline
Basement (Paparoa Batholith) igneous rocks	diorite	Kstfa	Fine-grained muscovite-biotite granodiorite	Separation Point Suite granodior	18_crystalline
Basement (Karamea Batholith) igneous rocks	granodiorite	Kstpe	Medium-grained biotite granodiorite	Separation Point Suite diorite	18_crystalline
Basement (Karamea Batholith) igneous rocks	diorite	Ksy	Mylonitised granitoid rocks (mostly Macey Granodiorite)	Separation Point Suite diorite	18_crystalline
Allochthonous rocks	basalt	Kt	Basalt pillow lava, with subvolcanic intrusives of basalt, dolerite and gabbro.		18_crystalline
Allochthonous rocks	basalt	Kt	Mainly basalt pillow lava, with subvolcanic intrusives of basalt, dolerite and gabbro; locally incorporating siliceous mudstone		18_crystalline
Allochthonous rocks	basalt	Kt	Basalt and pillow basalt, with subvolcanic intrusive. Local greenschist metamorphism; extensive zeolitisation.		18_crystalline
Allochthonous rocks	basalt	Ktb	Basaltic pillow lava and pillow breccia, with sills and dikes of basalt and dolerite.		18_crystalline
Allochthonous rocks	basalt	Ktb~	Basaltic pillow lava and pillow breccia, with sills and dikes of basalt and dolerite.		18_crystalline
Basement (Median Batholith) igneous rocks	diorite	Ktdi	Fine-medium grained, equigranular diorite with minor gabbro & quartz monzodiorite. Hornblendite & hbl-plag pegmatite dikes	diorite	18_crystalline
Allochthonous rocks	gabbro	Ktg	Basaltic pillow lava with minor intercalated mudstone anmd limestone, intruded by sills of gabbro and dolerite.		18_crystalline
Basement (Eastern Province) melange	sandstone	Ktm	Areas of melange of disrupted sandstone and /or mudstone dominated sequences with blocks of chert and basalt	Torlesse Supergroup	15_undifSed
Allochthonous rocks	gabbro	Ktm	Layered and massive plutonic gabbro, overthrust over Surville Serpentinite.		18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Median Batholith) igneous rocks	granodiorite	Ktmp	Fine-medium grained biotite granodiorite and granite; mostly equigranular but locally K-feldspar megacrystic	granodiorite	18_crystalline
Basement (Eastern Province) sedimentary rocks	sandstone	Ktp	Thick; porly bedded sandstone; well bedded; commonly graded sandstone and mudstone; minor volcanic rocks		15_undifSed
Basement (Eastern Province) sedimentary rocks	greywacke	Ktp	well bedded sandstone and mudstone	Torlesse	15_undifSed
Allochthonous rocks	breccia	Ktp	Poorly sorted, polymict igneous breccia of basalt, dolerite and gabbro, with minor intercalated volcaniclastic sandstone and tuf		15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Ktp	Indurated sandstone & mudstone with minor basaltic volcanics, chert, & dolomitic limestone	Pahau greywacke	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Ktp	Alternating sandstone and mudstone, massive mudstone and concretionary mudstone		15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Ktp	Thick, poorly bedded sandstone, well bedded, commonly graded sandstone and mudstone with minor volcanic rocks	Pahau undiff.	15_undifSed
Basement (Eastern Province) sedimentary rocks	conglomerate	Ktpc	Lenses of well-rounded conglomerate.	Pahau conglomerate	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Ktph	Hornfelsed sandstone and mudstone close to the Tapuae-O-Uenuku intrusion	Pahau hornfelsed	15_undifSed
Basement (Eastern Province) melange	sandstone	Ktpm	Melange and broken formation comprising weak-strongly sheared mudstone enveloping lenticular sandstone and minor coloured mudsto	Pahau melange	15_undifSed
Basement (Eastern Province) sedimentary rocks	chert	Ktpt	White fine grained siliceous chert, commonly closely jointed or brecciated.	Pahau chert	15_undifSed
Basement (Eastern Province) igneous rocks	basalt	Ktpv	Spilitic basalt; dolerite and camptonite		18_crystalline

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Basement (Eastern Province) igneous rocks	basalt	Ktpv	Spilitic basalt; dolerite and camptonite	Pahau volcanics	18_crystalline
Basement (Western Province) igneous rocks	basalt	Ktpv	Spilitic basalt; dolerite and camptonite		18_crystalline
Allochthonous rocks	breccia	Ktp~	Poorly sorted, polymict igneous breccia of basalt, dolerite and gabbro, with minor intercalated volcaniclastic sandstone and tuf		15_undifSed
Allochthonous rocks	peridotite	Kts	Partly and wholly serpentinised peridotite at North Cape.		18_crystalline
Allochthonous rocks		Kts	Serpentinite pod.		15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Ktw	Greywacke, argillite, conglomerate	greywacke	15_undifSed
Basement (Eastern Province) sedimentary rocks	greywacke	Ktw	alternating sandstone and mudstone, thick sandstone	greywacke	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Ktw	Well-bedded alternating sandstone and mudstone		15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Ktw	greywacke, argillite, conglomerate		15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Ktw			15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Ktwo	Greywacke, argillite, conglomerate	Omaio petrofacies	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Ktwo~	Greywacke, argillite, conglomerate, minor chert in melange	Omaio petrofacies	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Ktww	Greywacke, argillite, conglomerate	Waioeka greywacke	15_undifSed

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Allochthonous rocks	sandstone	Ku	Strongly indurated, poorly stratified conglomerate, sandstone and argillite.		15_undifSed
Allochthonous rocks	conglomerate	Ku	Strongly indurated, massive to poorly bedded conglomerate, pebbly sandstone and sandstone.		15_undifSed
Basement metamorphic rocks	phyllonite	Kw	Fine grained well foliated phyllonite tectonised breccia and sandstone	Wakapuaka Phyllonite	18_crystalline
Neogene sedimentary rocks	limestone	MPg	Repeated sequences of limestone, sandstone, mudstone and minor conglomerate		15_undifSed
Neogene sedimentary rocks	conglomerate	MPld	Deformed weathered sandy conglomerate derived from Rakaia terrane greywacke and schis; basal quartz-lithic gravel and sand		15_undifSed
Neogene sedimentary rocks	conglomerate	MPm	Sandy conglomerate with clasts of weathered rounded greywacke or angular, locally derived, schist; minor sand; may be auriferous	conglomerate	15_undifSed
Neogene sedimentary rocks	conglomerate	MPp	massive to crossbedded ,weathered, greywacke conglomerate; sandstone interbeds; mudstone units to 50m; largely Caples derived	conglomerate	15_undifSed
Neogene sedimentary rocks	breccia	MPs	Sandy to bouldery schist breccia resting on basal quartz-lithic sandstone (not differentiated); may be auriferous	conglomerate	15_undifSed
Basement (Median Batholith) igneous rocks	diorite	MZlwd	Medium-coarse grained, variably foliated, equigranular two-pyroxene (replaced by amphibole) diorite; granitoid & pegmatite dikes	diorite	18_crystalline
Neogene sedimentary rocks	sandstone	Mam	Conglomerate grading upwards into sandstone with conglomerate lenses and mudstone and siltstone	Medway Formation	15_undifSed
Neogene sedimentary rocks	siltstone	Mau	Poorly sorted and poorly bedded channelised greywacke conglomerate with lenses of sandstone and sandy siltstone	Upton Formation	15_undifSed
Neogene sedimentary rocks	conglomerate	Mau	Poorly sorted and poorly bedded channelised graywacke conglomerate with lenses of sandstone and sandy siltstone		15_undifSed
Paleogene - Neogene sedimentary rocks	sandstone	Mb	Hard calcareous sandstone & sandy mudstone; conglomeratic (greywacke/granite) limestone at base; sandy limestone at top	Miocene Mikonui sediment	15_undifSed

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Neogene sedimentary rocks	siltstone	Mb	Blue-grey calcareous siltstone and mudstone basal calcareous sandstone	Cover	15_undifSed
Neogene sedimentary rocks	mudstone	Mb_t	Grey calcareous mudstone	Miocene Omoeroa sediment	15_undifSed
Neogene igneous rocks	andesite	Mca	Andesitic and dacitic lava flows and domes, intrusives, tuff and tuff breccias, volcaniclastic sediments, and welded dacitic ign		18_crystalline
Neogene igneous rocks	granodiorite	Mcc	Granodiorite to diorite, with minor aplites and pegmatites.		18_crystalline
Neogene igneous rocks	andesite	Mci	Andesite, dacite and rhyodacite flows and domes with intercalated tuff, tuff breccia and volcaniclastic sediments. Local, non-we		18_crystalline
Neogene igneous rocks	granitoid	Mck	Plutons of quartz monzonite to adamellite and diorite to quartz monzodiorite. Microdiorite near North Cape.		18_crystalline
Neogene igneous rocks	tuff	Mcm	Rhyodacitic within lithic-volcanic to lithic sedimentary deposits.		18_crystalline
Neogene igneous rocks	andesite	Mco	Andesite and dacite intrusives and lava flows with minor intercalated tuff and tuff breccias.		18_crystalline
Neogene igneous rocks	quartz diorite	Mcp	Quartz diorite to granodiorite, with minor aplites and pegmatites.		18_crystalline
Neogene igneous rocks	dacite	Mcrd	Dacite domes and vent-filling breccia, locally altered to halloysitic clay.	Dacite	18_crystalline
Neogene igneous rocks	andesite	Mcri	Andesite, diorite and granodiorite intrusions.	Intrusions	18_crystalline
Neogene igneous rocks	volcanic breccia	Mcrv	Weakly stratified to massive, rubbly andesitic breccia, andesite flows and minor tuff.	Volcaniclastics and flows	17_volcanic
Neogene igneous rocks	sinter	Mct	Quartz sinter, forming terraces and plugs.		18_crystalline
Neogene igneous rocks	andesite	Mcu	Basaltic andesite, andesite and dacite intrusives, flows, volcaniclastites and volcanic epiclastites.		18_crystalline
Neogene igneous rocks	andesite	Mcu	Pyroxene and amphibole andesitic and dacitic predominantly flow banded and jointed lava; volcanic breccia; volcaniclastic mudsto	[Within Auckland Mca Kaimai subg	18_crystalline
Neogene igneous rocks	dacite	Mcu	Dacite		18_crystalline
Neogene igneous rocks	breccia	Mcw	Andesitic breccia and agglomerate.		18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Neogene igneous rocks	andesite	Mcwi	Subvolcanic intrusive andesite; andesite, diorite and porphyry dikes.	Intrusions	18_crystalline
Neogene igneous rocks	volcanic breccia	Mcwv	Laharic and minor vent-filling andesitic breccia, lava flows, fluvial and lacustrine sandstone and mudstone.	Breccia, flows and sediments	17_volcanic
Neogene igneous rocks	trachyte	Md0e	trachytic flows and tuffs	initial eruptive phase	18_crystalline
Neogene igneous rocks	trachyte	Md0i	dikes and plugs of anorthoclase trachyte	initial eruptive phase	18_crystalline
Neogene sedimentary rocks	trachyte	Md0p	breccia and basaltic agglomerate	initial eruptive phase	15_undifSed
Neogene igneous rocks	basalt	Md1e	extensive flows of olivine basalt plagioclase basalt basanite kaiwekite and trachyandesite	first main eruptive phase	18_crystalline
Neogene igneous rocks	phonolite	Md1i	shallow intrusions of nepheline syenite porphyry tinguaite and trachyandesite	first main eruptive phase	18_crystalline
Neogene sedimentary rocks	breccia	Md1p	vent filling breccia and agglomerate	first main eruptive phase	15_undifSed
Neogene igneous rocks	basalt	Md2e	extensive flows of trachybasalt olivine dolerite basalt phonolite	second main eruptive phase	18_crystalline
Neogene igneous rocks	dolerite	Md2i	plugs of dolerite porphyrite phonolite and tinguaite	second main eruptive phase	18_crystalline
Neogene sedimentary rocks	breccia	Md2p	vent filling breccia	second main eruptive phase	15_undifSed
Neogene igneous rocks	basalt	Md3e	extensive flows of phonolite basalt trachyandesite minor tuff	third main eruptive phase	18_crystalline
Neogene sedimentary rocks	basalt	Md3p	lapilli tuff agglomerate volcanic breccia minor trachytic flows	third main eruptive phase	15_undifSed
Neogene sedimentary rocks	conglomerate	Mdc	generally lenticular deposits of conglomerate in formed stream channels finer deposits in ephemeral lakes	flood plain alluvium	15_undifSed
Neogene sedimentary rocks	diatomite	Mdd	diatomite and carbonaceous sapropel as lake deposits in maar crater at Foulden Hills		15_undifSed
Neogene sedimentary rocks	breccia	Mdp	basaltic breccia and agglomerate in outliers to Dunedin volcanic complex	agglomerate breccia	15_undifSed

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Neogene igneous rocks	basalt	Mdv	Alkali basalt lava flows, plugs, agglomerate, tuff and shallow intrusions including those offshore; dikes		18_crystalline
Neogene igneous rocks	basalt	Mdv	undifferentiated flows pyroclastics and intrusives peripheral to the Dunedin volcanic complex	undifferentiated volcanics	18_crystalline
Neogene sedimentary rocks	sandstone	Mga	Repeated sequences of sandstone, siltstone, shellbeds and minor conglomerate		15_undifSed
Neogene sedimentary rocks	limestone	Mga	Repeated sequences of limestone, sandstone, mudstone and minor conglomerate		15_undifSed
Neogene sedimentary rocks	sandstone	Mgk	Massive to finely laminated siltstone and sandstone with discontinuous sandstone, conglomerate and limestone channel fill sequen		15_undifSed
Neogene sedimentary rocks	sandstone	Mgm	Interbedded fine to very fine sandstone and mudstone or siltstone, with some channelised conglomerate horizons; massive mudstone		15_undifSed
Neogene sedimentary rocks	mudstone	Mgmk	Interbedded fine to very fine sandstone and mudstone or siltstone; massive mudstone	Mount Messenger Formation (Kohu member)	15_undifSed
Neogene sedimentary rocks	siltstone	Mgu	Medium to light grey, weakly bedded, bioturbated siltstone and mudstone with incised, coarse channel-fill sequences.		15_undifSed
Neogene igneous rocks	ignimbrite	Mhc	Ignimbrite flow sheets and local rhyolitic and obsidian-rich pumice breccia deposits and tuff.		18_crystalline
Neogene igneous rocks	rhyolite	Mhm	Rhyolite flow and dome complexes with associated breccia and tuff; extensive hydrothermal alteration.		18_crystalline
Neogene igneous rocks	rhyolite	Mhm	Rhyolite flow and dome complexes with associated breccias and tuffs.		18_crystalline
Neogene sedimentary rocks	conglomerate	MiPlp	Cross-bedded sandstone, overlain by massive to thick-bedded, sandy conglomerate (largely Fiordland clasts); rare lignite	conglomerate	15_undifSed
Neogene sedimentary rocks	conglomerate	MiPlp	massive to crossbedded conglomerate with minor sandstone and local breccia	conglomerate	15_undifSed
Paleogene - Neogene sedimentary rocks	sandstone	Miec	fossiliferous sandstone with mudstone and shellbeds	sandstone	15_undifSed
Neogene sedimentary rocks	sandstone	Mieg	sandstone with lignite and carbonaceous mudstone; mudstone; claystone and minor conglomerate	sandstone	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Neogene sedimentary rocks	quartzite	Miegc	silicified quartz sandstone and conglomerate	quartzite	15_undifSed
Paleogene - Neogene sedimentary rocks	claystone	Miep	claystone with carbonaceous mudstone and minor shellbeds and sandstone	claystone	15_undifSed
Neogene sedimentary rocks	sandstone	Mit	thick sandstone, algal limestone and fossiliferous mudstone	algal limestone	15_undifSed
Neogene sedimentary rocks	algal limestone	Mitl	algal limestone	algal limestone	15_undifSed
Neogene sedimentary rocks	limestone	Miul	soft to cemented shelly limestone	limestone	15_undifSed
Neogene sedimentary rocks	sandstone	Miw	well bedded alternating sandstone and mudstone with interbedded olistostrome deposits		15_undifSed
Neogene sedimentary rocks	sandstone	Miwa	Massive to m-bedded blue-grey fine-medium sandstone with minor shellbeds; becomes finer and muddier westward	sandstone	15_undifSed
Neogene sedimentary rocks	sandstone	Miwa	massive sandstone with rare shellbeds	marine sandstone	15_undifSed
Neogene sedimentary rocks	sandstone	Miwb	Graded sandstone and mudstone of turbiditic origin	sandstone	15_undifSed
Neogene sedimentary rocks	sandstone	Miwb	Basal thick-bedded sandstone overlain by thinner bedded sandstone & subordinate mudstone; beds are graded	sandstone	15_undifSed
Neogene sedimentary rocks	sandstone	Miwb	Basal thick-bedded sandstone overlain by thinner bedded sandstone & subordinate mudstone; beds are graded; calcareous	sandstone	15_undifSed
Neogene sedimentary rocks	sandstone	Miwc	sandstone with shellbeds; laminated siltstone; locally with lignite	sandstone	15_undifSed
Neogene sedimentary rocks	conglomerate	Miwc	Coarse sandy, pebble to cobble conglomerate and pebbly sandstone	conglomerate	15_undifSed
Neogene sedimentary rocks	limestone	Miwcg	Graded, sandy to pebbly, bioclastic limestone and siltstone; with secondary cemetation	limestone	15_undifSed
Neogene sedimentary rocks	sandstone	Miwd	Graded, commonly slump-folded, thin-bedded & laminated sandstone, siltstone, mudstone and rare conglomerate	sandstone	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Neogene igneous rocks	basaltic andesite	Mkm	Pyroxene basaltic andesite, pyroxene andesite, hornblende andesite and hornblende dacite breccia, agglomerate, tuff, lava and di	Miranda unit	18_crystalline
Neogene igneous rocks	basaltic andesite	Mkt	Pyroxene basaltic andesite and pyroxene andesite lava and breccia.	Tahuna unit	18_crystalline
Neogene igneous rocks	basaltic andesite	Mkt	Olivine basaltic andesite lava and breccia.	Tahuna unit	18_crystalline
Neogene igneous rocks	andesite	Mkw	Pyroxene andesite and hornblende andesite agglomerate and breccia.	Waiheke unit	18_crystalline
Neogene sedimentary rocks	conglomerate	Ml	Fluvial conglomerate with sandstone, mudstone and coal seams.	Longford Formation	05_fluvialEstuarine
Neogene sedimentary rocks	mudstone	Ml	mudstone, minor sandstone.	Ruatahuna outlier	15_undifSed
Paleogene - Neogene sedimentary rocks	sandstone	Mm	Quartz- mica sandstone; locally glauconitic; and alternating sandstone and mudstone	Matiri Formation	15_undifSed
Neogene sedimentary rocks	sandstone	Mm	Quartz-mica sandstone and mudstone graded beds, locally sandstone dominated, with thick conglomerate, grading up into sandstone	undiff. Mangles Formation	15_undifSed
Neogene sedimentary rocks	sandstone	Mm	Medium to fine grained quartz-mica sandstone locally glauconitic siltstone and massive sandstone beds	Cover	15_undifSed
Neogene sedimentary rocks	sandstone	Mma	Muddy fine-medium grained sandstone with pebble layers.	undiff. Mangles Formation	15_undifSed
Neogene sedimentary rocks	conglomerate	Mmc	Conglomerate, sandstone and mudstone in graded beds.	undiff. Mangles Formation	15_undifSed
Neogene sedimentary rocks	mudstone	Mmg	Blue-grey, calcareous, massive mudstone with concretion layers and some bioclastic sandstone beds.		15_undifSed
Neogene sedimentary rocks	sandstone	Mmt	Graded sandstone and calcareous mudstone with thick sandstone dominant in west.	undiff. Mangles Formation	15_undifSed
Neogene sedimentary rocks	sandstone	Mn	Blue-grey calc, sandy zst; brown, calc sst with 40m thick limestone (west) & conglomerate beds; calcareous glauconitic sandy zst	Miocene sediments	15_undifSed
Neogene sedimentary rocks	sandstone	Mn	Blue-grey calcareous, sandy zst w congl beds in SW; brown, calcareous sst, locally w limestone beds; calcareous glauc sandy zst	Miocene sediments	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Neogene sedimentary rocks	sandstone	Mn	Undifferentiated sandstone and siltstone, includes Mt Brown and Waikari formations.	undifferentiated Motunau Group	15_undifSed
Neogene sedimentary rocks	siltstone	Mn	Blue-grey calcareous, sandy zst with 2 fossiliferous pebble conglomerate bands (Double Corner Shell Beds)	Miocene sediments	15_undifSed
Neogene sedimentary rocks	sandstone	Mn	Blue-grey calcareous, sandy zst; brown, calcareous sst, locally with limestone beds; grey calcareous glauconitic sandy zst	Miocene sediments	15_undifSed
Neogene sedimentary rocks	sandstone	Mn	Blue-grey calcareous, sandy zst; brown, calcareous sst, with 20m thick limestone bed; grey calcareous glauconitic sandy zst	Miocene sediments	15_undifSed
Paleogene - Neogene sedimentary rocks	claystone	Mn_w	Quartzose claystone and sandstone; commonly carbonaceous; local lignite; minor siltstone conglomerate or shell beds	Late Tertiary coal measures	15_undifSed
Neogene sedimentary rocks	sandstone	Mnb	Siltstone, sandstone and bioclastic limestone with interbedded debris flow conglomerate	Mount Brown Formation	15_undifSed
Neogene sedimentary rocks	sandstone	Mnb_	Siltstone, sandstone and bioclastic limestone with interbedded debris flow conglomerate	undifferentiated Miocene	15_undifSed
Neogene sedimentary rocks	sandstone	Mne	Green-grey, friable, fine quartz-rich sand with <5% glauconite	Brechin Formation	15_undifSed
Neogene sedimentary rocks	sandstone	Mne	Light brown sandstone with calcified bands, greywacke conglomerate at base (Gage 1956)	Brechin Formation	15_undifSed
Neogene sedimentary rocks	conglomerate	Mne	Fluvial greywacke-clast conglomerate and minor sst with local basal units of gabbro-clast conglomerate, marine sst, & mudstone	Brechin Formation	05_fluvialEstuarine
Neogene sedimentary rocks	conglomerate	Mne	Fluvial greywacke-clast conglomerate w local basal units of reworked tuff & limestone, gabbro-clast cglt, marine sst, & mudstone	Brechin Formation	05_fluvialEstuarine
Paleogene - Neogene sedimentary rocks	sandstone	Mne	Fault-bounded sliver of yellow sands, conglomerate, coal (Brechin Frm) and Eocene tuff+limestone (View Hill Volc)	View Hill Volc and Brechin Frm	15_undifSed
Neogene sedimentary rocks	sandstone	Mne	Sandstone with shell beds and concretions, disturbed by numerous faults	Brechin Formation	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Neogene sedimentary rocks	siltstone	Mne	Pale green siltstone and carbonacous mudstone. Minor pebbly sst at top. Coal, basalt-clast conglomerate, shellbeds at base	Enys Formation	15_undifSed
Neogene sedimentary rocks	siltstone	Mnk	Calcareous, glauconitic siltstone, massive, blue-grey siltstone, and bedded, yellow-brown sandstone	Waikari Formation	15_undifSed
Neogene sedimentary rocks	siltstone	Mnk_	Calcareous, glauconitic siltstone, massive, blue-grey siltstone, and bedded, yellow-brown sandstone	Waikari Formation	15_undifSed
Neogene sedimentary rocks	siltstone	Mnk_	Calcareous, glauconitic siltstone, massive, blue-grey siltstone, and bedded, yellow-brown sandstone	undifferentiated Miocene	15_undifSed
Neogene sedimentary rocks	siltstone	Mnw	Massive to poorly-bedded, bluish-grey calcareous silty mudstone; in the north includes lenses of poorly-sorted pebble to boulder	Waima Formation	15_undifSed
Neogene sedimentary rocks	sandstone	Mo	calcareous sandstone sandy limestone and minor tuff	marine sediments	15_undifSed
Neogene sedimentary rocks	sandstone	Mo	Blue-grey siltstone sandstone and carbonaceous mudstone in shallowing-up sequence (north of Waihemo FZ); outer-shelf sandstone a		15_undifSed
Neogene sedimentary rocks	conglomerate	Moo	Cobble and pebble conglomerate derived mainly from Tangihua Complex. Locally interfingered with Waipoua basalt flows.		15_undifSed
Neogene sedimentary rocks	conglomerate	Moo~	Cobble and pebble conglomerate derived mainly from Tangihua Complex. Locally interfingered with Waipoua basalt flows.		15_undifSed
Neogene sedimentary rocks	mudstone	Mop	Calcareous mudstone with intercalated sandstone and breccia derived from the Northland Allochthon.		15_undifSed
Neogene sedimentary rocks	mudstone	Mot	Massive to poorly bedded mudstone and muddy sandstone.		15_undifSed
Neogene sedimentary rocks	mudstone	Mot	Massive to poorly bedded mudstone and muddy fine-grained sandstone .		15_undifSed
Neogene sedimentary rocks	conglomerate	Mow	Conglomerate and sandstone derived from the Northland Allochthon.		15_undifSed
Neogene sedimentary rocks	conglomerate	Mpk	Poorly bedded sandstone and coglomerate derived from Coromandel Group volcanoes.		15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Neogene sedimentary rocks	conglomerate	Mppm	Poorly to moderately bedded sandstone, pebbly and bouldery sandstone, and conglomerate at Matapia Island.		15_undifSed
Neogene sedimentary rocks	sandstone	Mppp	Muddy fine-grained sandstone with pebble to boulder conglomerate, pebbly sandstone and pebbly mudstone.		15_undifSed
Neogene sedimentary rocks	sandstone	Mpt	Basal shelly breccia overlain by mudstone and muddy sandstone, with minor tuff and lapilli tuff.		15_undifSed
Neogene sedimentary rocks	conglomerate	Ms	alluvial conglomerate with shallow marine sandstone, mudstone and bioclastic limestone		15_undifSed
Neogene sedimentary rocks	mudstone	Msb	Massive blue-grey calcareous mudstone with sparse fossils and discontinuous limestone lenses and sparse tuff beds		15_undifSed
Neogene sedimentary rocks	conglomerate	Msp	Mod-poorly bedded; silty sandstone; and sandy siltstone; minor grit; mod-well bedded sandstone and calcareous sandstone		15_undifSed
Neogene sedimentary rocks	sandstone	Mta	Thin bedded sandstone and mudstone, locally with thick coarse-grained sandstone and grit beds.		15_undifSed
Neogene sedimentary rocks	vitric tuff	Mth	Hard, fine-grained, brown hyaloclastic tuff.		15_undifSed
Neogene igneous rocks	basaltic andesite	Mti	Basaltic andesite flows and pillow lavas intruded by feeder dikes.		18_crystalline
Neogene sedimentary rocks	volcanic sandstone	Mtk	Thick-bedded, muddy, volcaniclastic sandstone and fossiliferous mudstone.		17_volcanic
Neogene sedimentary rocks	volcanic sandstone	Mtk	Thick-bedded, muddy volcaniclastic sandstone and mudstone.		17_volcanic
Neogene igneous rocks	andesite	Mtl	Andesite flows and pyroclastics, plugs, diatremes, clastic dikes, shallow intrusives and crater-fills, with minor flow-banded da		18_crystalline
Neogene sedimentary rocks	conglomerate	Mtm	Massive to crudely bedded , cobble and pebble conglomerate with thin bedded mudstone.		15_undifSed
Neogene sedimentary rocks	volcanic sandstone	Mtn	Submarine volcaniclastic grit, sandstone and siltstone.		17_volcanic
Neogene sedimentary rocks	volcanic sandstone	Mtn+Mtp	Submarine volcaniclastic grit, sandstone and siltstone.		17_volcanic

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Neogene igneous rocks	volcanic breccia	Mto	Basaltic andesite, hyaloclastite breccia and tuff with minor basaltic pillow lava.		17_volcanic
Neogene sedimentary rocks	volcanic conglomerate	Mtp	Stratified, submarine andesitic breccio-conglomerate with minor grit, sandstone and siltstone.		17_volcanic
Neogene sedimentary rocks	volcanic conglomerate	Mtp~	Stratified, submarine andesitic breccio-conglomerate with minor grit, sandstone and siltstone.		17_volcanic
Neogene sedimentary rocks	volcanic sandstone	Mtr	Volcaniclastic sandstone and breccia.		17_volcanic
Neogene sedimentary rocks	volcanic sandstone	Mtr	Proximal, marine volcaniclastic sandstone and breccia.		17_volcanic
Neogene igneous rocks	breccia	Mtsb	Pyroclastic dikes and breccia pipes.	Breccia pipes	18_crystalline
Neogene igneous rocks	andesite	Mtsi	Basaltic, andesitic and dacitic necks, dikes, sills and laccoliths.	Intrusions	18_crystalline
Neogene sedimentary rocks	volcanic conglomerate	Mtt	Local channel-fill volcanic conglomerate and sandstone.		17_volcanic
Neogene sedimentary rocks	volcanic breccia	Mtu	Laharic andesite tuff-breccia, pumiceous pyroclastic flow deposits and tuff, with lignite and soil horizons.		17_volcanic
Neogene sedimentary rocks	sandstone	Mtu~	Alternating sandstone/mudstone.		15_undifSed
Neogene igneous rocks	basalt	Mtw	Basalt lava flows and thin interbedded tuff and lapilli.		18_crystalline
Neogene igneous rocks	basalt	Mtw	Basalt flows, pillow lavas, hyaloclastites and associated intrusives, with minor basic andesite.		18_crystalline
Neogene igneous rocks	basalt	Mtw	Plateau-forming basalt, tuff and lapilli derived from the offshore Waipoua volcano; in many places very deeply weathered.		18_crystalline
Neogene igneous rocks	basalt	Mtw~	Plateau-forming basalt, tuff and lapilli derived from the offshore Waipoua volcano; in many places very deeply weathered.		18_crystalline
Neogene sedimentary rocks	sandstone	Mub	White, medium quartzose sandstone; also coarse to small pebble sst. Includes Eocene tuffaceous sst & gritty sst in NW.	Bradley/View Hill Volc/Marine Dr	15_undifSed
Neogene sedimentary rocks	sandstone	Muu	Basalt breccia&tuff sst(Wairiri); feldspathic sst(Chalk Quarry); clay(Chalk Hill); tuff (Sandpit;) basalt breccia&flows (Bluff)	Burnt Hill Group	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Neogene igneous rocks	basalt	Muv	Dark grey fine grained porphyritic & vesicular tholeiitic basalt lava flows. Up to three flows, oldest is 15 m thick.	Harper Hills Basalt	18_crystalline
Neogene igneous rocks	basalt	Muv	Porphyritic&vesicular tholeiitic basalt lava flows. Up to 3 flows, oldest is 15 m thick. Overlain by Coalgate Bentonite	Harper Hills Basalt	18_crystalline
Neogene igneous rocks	trachyte	Mva	Massive, coarse to fine grained, trachyte to microsyenite dome	Akaroa volcanics	18_crystalline
Neogene igneous rocks	tuff	Mva	Polylithic trachytic breccia to lapilli tuff	Akaroa volcanics	18_crystalline
Neogene igneous rocks	hawaiite	Mva	Basaltic to trachytic lava flows (mainly hawaiite composition) intercalated with tuff, pyroclastic breccia, and agglomerate	Akaroa volcanics	18_crystalline
Neogene igneous rocks	syenite	Mvas	Syenite and minor gabbro; hawaiite lava flows and trachyitic breccia	Akaroa syenite	18_crystalline
Neogene igneous rocks	basalt	Mvd	Basaltic (basinite, basalt, hawaiite) lava flows, dikes, vent plugs, sills; minor interbeds of breccia, congl, sst, carbonac mst	Diamond Harbour volcanics	18_crystalline
Neogene igneous rocks	basalt	Mvd	Basaltic (basinite, basalt, hawaiite) flows, dikes, vent plugs, sills; & a dome, interbeds of breccia, congl, sst, carbonac mst	Diamond Harbour volcanics	18_crystalline
Neogene igneous rocks	andesite	Mvgb	Flow-banded plagioclase-pyroxene-olivine porphyritic andesitic lava flows	Governors Bay Andesite	18_crystalline
Neogene igneous rocks	hawaiite	Mvh	Basaltic lava flows & plugs; minor interbedded volcaniclastic breccia, conglomerate, sst, siltstone, carbonaceous mst, & tuff	Mt Herbert volcanics	18_crystalline
Neogene igneous rocks	hawaiite	Mvl	Basaltic (hawaiite) to trachytic lava flows interbedded with tuff and breccia (including lahars), many dikes & minor lava domes	Lyttelton volcanics	18_crystalline
Neogene igneous rocks	basalt	Mvm	Olivine and olivine-augite basalt to pyroxene basalt and basaltic andesite flows, pyroclastites, dikes and sills.		18_crystalline
Neogene igneous rocks	rhyolite	Mvra	Flow-banded porphyritic rhyolite & dacite lava flows & domes; local rhyolite breccias around dome bases; rare tuffs and obsidian	Allandale Rhyolite	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Neogene igneous rocks	basalt	Mvt	Olivine basalt and olivine basaltic andesite flow remnants and dikes.		18_crystalline
Neogene igneous rocks	olivine basalt	Mvt	Olivine basalt flow remnants		18_crystalline
Neogene sedimentary rocks	turbidite	Mwa	Alternating, graded sandstone and mudstone, with interbedded, thin volcaniclastic grits.		15_undifSed
Allochthonous rocks	mudstone	Mwb	Thin-bedded mudstone, sandy siltstone and rippled muddy fine-grained sandstone, with minor graded, medium-grained to fine-grain		15_undifSed
Neogene sedimentary rocks	mudstone	Mwb	Thin-bedded mudstone, sandy siltstone and rippled muddy fine sandstone, with minor graded, medium to fine sandstone.		15_undifSed
Neogene sedimentary rocks	volcanic sandstone	Mwc	Thick-bedded, graded, pebbly and gritty volcanic sandstone and thin-bedded fine sandstone and siltstone.		17_volcanic
Neogene sedimentary rocks	volcanic sandstone	Mwc~	Thick-bedded, graded, pebbly and gritty volcanic sandstone and thin-bedded fine sandstone and siltstone.		17_volcanic
Neogene sedimentary rocks	sandstone	Mwd	Alternating graded sandstone and mudstone.	undifferentiated	15_undifSed
Neogene sedimentary rocks	turbidite	Mwe	Alternating sandstone and mudstone with variable volcanic content and interbedded volcaniclastic grits.		15_undifSed
Neogene sedimentary rocks	turbidite	Mwe~	Alternating sandstone and mudstone with variable volcanic content and interbedded volcaniclastic grits.		15_undifSed
Allochthonous rocks	mudstone	Mwf	Massive, white to grey, calcareous mudstone to siltstone with minor tuff.		15_undifSed
Neogene sedimentary rocks	siltstone	Mwg	Laminated to thin-bedded, calcareous siltstone with rare, interbedded shelly sandstone.		15_undifSed
Allochthonous rocks	siltstone	Mwg	Laminated to thin-bedded, calcareous siltstone with rare, interbedded shelly sandstone.		15_undifSed
Neogene sedimentary rocks	sandstone	Mwh	Thick-bedded, graded, calcareous sandstone with minor interbedded mudstone.	Hoteo beds	15_undifSed
Neogene sedimentary rocks	sandstone	Mwh	regularly bedded graded sandstone and mudstone	flysch	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Neogene sedimentary rocks	mudstone	Mwi	Thin-bedded mudstone, sandy siltstone and rippled muddy fine-grained sandstone.		15_undifSed
Neogene sedimentary rocks	mudstone	Mwi	Thin-bedded mudstone, sandy siltstone and rippled muddy fine sandstone.		15_undifSed
Neogene sedimentary rocks	siltstone	Mwk	Calcareous, sandy siltstone with minor fine sandstone and tuff beds.		15_undifSed
Neogene sedimentary rocks	conglomerate	Mwl	Conglomerate, composed mainly of well-rounded, boulder-, cobble- and pebble-size clasts of andesite, with less microdiorite, spi		15_undifSed
Neogene sedimentary rocks	sandstone	Mwm	Massive, non-calcareous, fine to coarse sandstone and thin sandy mudstone, with carbonaceous fragments and abundant volcanic gla		15_undifSed
Neogene sedimentary rocks	sandstone	Mwn	Thick-bedded, bioclastic sandstone.		15_undifSed
Neogene sedimentary rocks	conglomerate	Mwo	Conglomerate, composed of well-rounded, cobble- and pebble-size clasts of andesite, microdiorite, spillitic basalt, limestone an		15_undifSed
Neogene sedimentary rocks	sandstone	Mwp	Alternating thick-bedded, volcanic-rich, graded sandstone and siltstone.		15_undifSed
Neogene sedimentary rocks	turbidite	Mwp	Alternating, thick-bedded, volcanic-rich, graded sandstone and siltstone, with volcaniclastic grit beds.		15_undifSed
Allochthonous rocks	sandstone	Mwp	Alternating thick-bedded, volcanic-rich, graded sandstone and siltstone.		15_undifSed
Neogene sedimentary rocks	conglomerate	Mwr	Greywacke conglomerate and breccia with associated grit, pebbly medium to coarse sandstone, carbonaceous siltstone and shelly, p		15_undifSed
Neogene sedimentary rocks	sandstone	Mwt	Macrofossiliferous, massive or weakly bedded, calcareous sandstone.		15_undifSed
Neogene sedimentary rocks	sandstone	Mwt+Mwr	Macrofossiliferous, massive or weakly bedded, calcareous sandstone.		15_undifSed
Neogene sedimentary rocks	limestone	Mwu	Pebbly, gritty, shelly or sandy, bioclastic, crystalline or semicrystalline limestone, and local limestone breccia, with thin sh		15_undifSed
Neogene sedimentary rocks	turbidite	Mwv	Alternating lithic-volcanic sandstone and mudstone with andesitic grit.		15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Neogene sedimentary rocks	sandstone	Mww	Calcareous, glauconitic fine to medium sandstone with minor siltstone and tuff: locally concretionary near base.		15_undifSed
Neogene sedimentary rocks	sandstone	Mww	Calcareous, glauconitic fine to medium sandstone with minor siltstone and tuff; locally concretionary near base.		15_undifSed
Allochthonous rocks	mudstone	Mwx	Calcareous mudstone with sandstone and breccia derived from the Northland Allochthon.		15_undifSed
Neogene sedimentary rocks	conglomerate	Mwy	Conglomerate composed mainly of pebble- and boulder-size clasts of dolerite and spilitic basalt with less common sedimentary cla		15_undifSed
Allochthonous rocks	sandstone	Mwz	Flaggy, planar-bedded, calcareous, glauconitic sandstone, polymict breccia and pebble conglomerate.		15_undifSed
Paleogene - Neogene sedimentary rocks	sandstone	OMd	Massive mst & zst; thick bedded lithic sandstone and rare pebbly conglomerate towards top; shellbeds; thin bioclastic limestone	sandstone	15_undifSed
Paleogene sedimentary rocks	sandstone	OMd	Thick bedded, coarse-grained, quartzofeldspathic to lithic sandstone; graded sandstone-mudstone packets	sandstone	15_undifSed
Paleogene sedimentary rocks	sandstone	OMd	Thick bedded, coarse, quartzofeldspathic to lithic sandstone; graded sandstone-mudstone packets; minor pebbly muddy congomerate	sandstone	15_undifSed
Paleogene - Neogene sedimentary rocks	mudstone	OMw	massive calcareous mudstone; subordinate graded sandstone units; minor limestone lenses	mudstone	15_undifSed
Paleogene - Neogene sedimentary rocks	limestone	Oa	Hard, flaggy, white, bryozoan bioclastic to micritic limestone with basal conglomeratic and/or sandy facies	limestone	15_undifSed
Paleogene - Neogene sedimentary rocks	limestone	Oa	Hard, flaggy, white, bryozoan biclastic to micritic limestone with basal conglomeratic and/or sandy facies.	limestone	15_undifSed
Basement (Western Province) metamorphic rocks	amphibolite	Oa	Hornfelsed metasediment occuring as xenoliths within granite	amphibolite xenoliths	18_crystalline
Basement (Western Province) metamorphic rocks	sandstone	Ob	Quartz sandstone; shale and phyllite	Golden Bay Group	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Paleogene - Neogene sedimentary rocks	sandstone	Ob	3-4 m sequence of soft, quartzose, slightly glauconitic sandstone; bands of silt; scattered schist chips near base	Bob Cove Beds sandstone/lst	15_undifSed
Paleogene - Neogene sedimentary rocks	limestone	Ob	10 m of hard fossiliferous bioclastic limestone with thin schist breccia bands	Bob Cove Beds sandstone/lst	15_undifSed
Paleogene - Neogene sedimentary rocks	siltstone	Ob	Basal breccia, siltstone, limestone, sandstone, conglomerate, and olistromes; locally derived and strongly indurated	Bob Cove Beds sandstone/lst	15_undifSed
Basement (Western Province) metamorphic rocks	argillite	Ob	Undifferentiated quartz sandstone black shale and phyllite	Golden Bay Group	18_crystalline
Paleogene - Neogene sedimentary rocks	sandstone	Ob	Sandstone, limestone, siltstone, conglomerate and breccia, locally derived & strongly indurated, infaulted along Moonlight Fault	Bob Cove Beds sandstone/lst	15_undifSed
Basement (Western Province) metamorphic rocks	argillite	Oba	Quartzite sandstone and black siliceous shale containing graptolites	Aorangi Mine Formation	18_crystalline
Basement (Western Province) metamorphic rocks	schist	Obb	Quartz muscovite-chlorite schist and quartz-biotite schist	Golden Bay Schist	18_crystalline
Basement (Western Province) metamorphic rocks	argillite	Obd	Thin-bedded and laminated siltstone quartzite tightly folded	Douglas/Peel Formation	18_crystalline
Basement (Western Province) metamorphic rocks	argillite	Obl	Quartz sandstone siltstone graded sandstone black shale containing graptolites	Leslie/Slaty Creek Formation	18_crystalline
Paleogene sedimentary rocks	conglomerate	Oc	weathered pebble conglomerate and pebbly sandstone	conglomerate	15_undifSed
Paleogene sedimentary rocks	limestone	Oea	Pale grey, hard, bioturbated, fine grained, slightly glauconitic, micritic limestone. Stylolitic fractures common.	Amuri Limestone	15_undifSed
Paleogene sedimentary rocks	sandstone	Oee	Glauconitic, trough cross-bedded very fine sandstone with concreationary beds, and massive very fine sandy siltstone	Esk Formation	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Paleogene sedimentary rocks	sandstone	Oee	Pale green, cross bedded, glauconitic fine sandstone with concretionary beds; unconformable base marked locally by conglomerate	Esk Formation	15_undifSed
Paleogene sedimentary rocks	sandstone	Oee	Glauconitic, trough cross-bedded very fine sst & massive very fine sandy zst, shellbeds adjacent to Oev, thin congl at base (NE)	Esk Formation	15_undifSed
Paleogene sedimentary rocks	sandstone	Oee	Glauconitic, trough cross-bedded very fine sandstone and massive very fine sandy siltstone, thin greensand at top	Esk Formation	15_undifSed
Paleogene sedimentary rocks	sandstone	Oee	Glauconitic, trough cross-bedded very fine sandstone and massive very fine sandy siltstone	Esk Formation	15_undifSed
Paleogene igneous rocks	basalt	Oeev	Intrusive stock; basalt pillow lava; pillow breccia; tuff	Esk Formation	18_crystalline
Paleogene igneous rocks	basalt	Oeev	Basalt pillow lava; pillow breccia; tuff	Esk Formation	18_crystalline
Basement (Western Province) metamorphic rocks	quartzite	Off	Strongly sheared quartzite sandstone argillite and limestone	Fenella Fault Zone	18_crystalline
Basement (Western Province) metamorphic rocks	metasandstone	Og	interbedded quartzose, commonly graded, metasandstone & metamudstone;rare calc-silicate & tuff beds;slaty cleavage in finer rock	Greenland Group	18_crystalline
Basement (Western Province) metamorphic rocks	metasandstone	Og	Interbedded quartzose metasandstone & metamudstone with slaty cleavage; qtz-musc-biot schist & hornfels; minor congl & calc sst	greywacke	18_crystalline
Basement (Western Province) metamorphic rocks	sandstone	Og	Undifferentiated greenish-grey quartzose greywacke and argillite; locally hornfelsed close to granitoid plutons	Greenland Group	18_crystalline
Basement (Western Province) metamorphic rocks	metasandstone	Og	interbedded quartzose, commonly graded, metasandstone & metamudstone; rare calc-silicate; slaty cleavage in finer rocks	Greenland Group	18_crystalline
Basement (Western Province) metamorphic rocks	sandstone	Og	Undifferentiated quartz-muscovite sandstone shale and phyllite	Greenland Group	18_crystalline
Basement (Western Province) metamorphic rocks	metasandstone	Og	interbedded quartzose, commonly graded, metasandstone & metamudstone; rare calc-silicate & metadacite; slaty cleavage	Greenland Group	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Western Province) metamorphic rocks	metasandstone	Og	Schistose quartz-rich metasandstone & metamudstone w slaty cleavage; qtz-musc-biot schist & hornfels; rare congl & calc-silicate	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	sandstone	Og	Indurated; well-bedded quartz-muscovite greywacke sandstone & argillitic siltstone/mudstone; graded bedding common	Greenland Group greywacke	18_crystalline
Basement (Western Province) metamorphic rocks	hornfels	Ogh	Slightly to non-schistose Greenland Group biotite-hornblende hornfels & pyroxene-hornfels adjacent to plutons	Greenland Group hornfels	18_crystalline
Basement (Western Province) metamorphic rocks	paragneiss	Ogn	biotite+musc+/-sillimanite gneiss: foliated & med-coarse pelitic bands interlayered with finer grained massive metasandstone	Greenland Group	18_crystalline
Basement (Western Province) metamorphic rocks	paragneiss	Ogp	Biotite- garnet gneiss derived from Greenland Group sediments	Pecksniff Paragneiss	18_crystalline
Basement (Western Province) metamorphic rocks	sandstone	Ogr	Quartz-muscovite graded sandstone shale and phyllite	Webb Formation	18_crystalline
Basement (Western Province) metamorphic rocks	sandstone	Ogr	Quartz-mica graded sandstone siltstone and phyllite	Roaring Lion Formation	18_crystalline
Basement (Western Province) metamorphic rocks	schist	Ogs	Amphibolite-grade quartzofeldspathic schist (qtz+biot+/-musc+/-gar+/-sill)	Greenland Group schist	18_crystalline
Basement (Western Province) metamorphic rocks	paragneiss	Ogv	Biotite- garnet gneiss derived from Greenland Group sediments	Victoria Paragneiss	18_crystalline
Paleogene sedimentary rocks	limestone	Ogw	calcareous mudstone, greensand, sandstone, minor conglomerate, limestone.		15_undifSed
Paleogene sedimentary rocks	mudstone	Ogw	Calcareous mudstone, limestone and alternating sandstone and mudston		15_undifSed
Paleogene sedimentary rocks	mudstone	Ogw	Calcareous mudstone, greensand, sandstone, minor conglomerate, limestone.		15_undifSed
Allochthonous rocks	limestone	Ogw	Alternating sandy and muddy limestone, coarse sandstone, breccia-conglomerate.		15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Paleogene - Neogene sedimentary rocks	mudstone	Ogw	white weathered calcareous mudstone	calcareous mudstone	15_undifSed
Allochthonous rocks	mudstone	Ogw	Calcareous mudstone, greensand, sandstone, minor conglomerate, limestone.		15_undifSed
Allochthonous rocks	mudstone	Ogw-eMt	calcareous mudstone, sandstone		15_undifSed
Allochthonous rocks	limestone	Ogwl	Muddy limestone with minor sandstone and mudstone beds.		15_undifSed
Neogene sedimentary rocks	sandstone	Ogws~	Greensand	Whangara Greensand	15_undifSed
Paleogene sedimentary rocks	mudstone	Oj	Highly sheared calcareous mudstone and interbedded muddy limestone; allochthonous to surrounding Tititira Formation	Jackson Formation	15_undifSed
Paleogene - Neogene sedimentary rocks	limestone	OlMif	Calcareous sandstone overlain by variably pebbly bioclastic limestone. Upper part is interbedded sandy and more crystalline lst	limestone	15_undifSed
Neogene sedimentary rocks	limestone	OlMif	sandy to bioclastic limestone with local basal conglomerate; variably glauconitic	limestone	15_undifSed
Paleogene - Neogene sedimentary rocks	limestone	OlMiul	well bedded sandy limestone with calcareous sandstone interbeds within Waicoe Fmn	limestone	15_undifSed
Paleogene - Neogene sedimentary rocks	limestone	OlMiwc	sandy to bioclastic limestone with local basal conglomerate overlying sandstone	limestone	15_undifSed
Paleogene - Neogene sedimentary rocks	mudstone	OlMiwks	Pebbly to bouldery mudstone; massive mudstone; interbedded graded sandstone & mudstone packets (often slump folded)	mudstone	15_undifSed
Paleogene - Neogene sedimentary rocks	mudstone	OlMiwks	Pebbly to bouldery mudstone; massive mst; interbedded graded sst & mst packets; breccia-bearing limestone next to Hauroko Fault	mudstone	15_undifSed
Paleogene - Neogene sedimentary rocks	mudstone	OlMiww	Massive calcareous mudstone; subordinate graded sandstone lenses	mudstone	15_undifSed
Paleogene - Neogene sedimentary rocks	mudstone	OlMiww	mudstone with graded limestone; breccia and sandstone interbeds	mudstone	15_undifSed
Paleogene - Neogene sedimentary rocks	sandstone	OlMiwws	Graded to massive sandstone lense within background Waicoe Fmn mudstone	sandstone	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Paleogene - Neogene sedimentary rocks	sandstone	OlMiwws	cm-bedded graded bioclastic sandstone lense. Unit (lense) occurs within background Waicoe Fmn mudstone	sandstone	15_undifSed
Paleogene sedimentary rocks	tuff	Old	Tholeiitic alkalic scoria; crystal tuff; lapilli and breccia including Kakanui Mineral Breccia		15_undifSed
Paleogene igneous rocks	basalt	Oldb	Basanitic and basaltic flows; dikes; plugs and intrusive masses of Deborah Volcanics		18_crystalline
Paleogene igneous rocks	basalt	Olnc	Plugs, flows, pillows, dikes and sills of basalt; breccia, volcaniclastic sandstone and interbedded tuff	Cookson volcanics	18_crystalline
Paleogene sedimentary rocks	basalt	OlncOlni	Undifferentiated limestone, basalt, breccia, tuff and sandstone	undiff. Isolated Hill Limestone	15_undifSed
Paleogene igneous rocks	basalt	Olnc_	Plugs, flows, pillows, dikes and sills of basalt; breccia, volcaniclastic sandstone and interbedded tuff	Cookson volcanics	18_crystalline
Paleogene igneous rocks	basalt	Olnc_	Plugs, flows, pillows, dikes and sills of basalt; breccia, volcaniclastic sandstone and interbedded tuff	undifferentiated Oligocene	18_crystalline
Paleogene sedimentary rocks	limestone	Olni	Limestone and calcareous mudstone with basal greensand.	Isolated Hill Limestone	15_undifSed
Paleogene sedimentary rocks	limestone	Olni_	Limestone and calcareous mudstone with basal greensand.	undifferentiated Oligocene	15_undifSed
Paleogene sedimentary rocks	limestone	Olnt	Limestone and calcareous mudstone with basal greensand.	Tekoa Limestone	15_undifSed
Paleogene - Neogene sedimentary rocks	limestone	Olnw	Limestone and calcareous mudstone with basal greensand.	Weka Pass Stone	15_undifSed
Paleogene sedimentary rocks	limestone	Olnw_	Limestone and calcareous mudstone with basal greensand.	undifferentiated Oligocene	15_undifSed
Paleogene sedimentary rocks	limestone	Olul	limestone and fossiliferous sandstone with basal conglomerate; siltstone and shellbeds	limestone	15_undifSed
Paleogene sedimentary rocks	sandstone	Olwb	graded sandstone and mudstone with basal breccia; fining upward to mudstone	sandstone	15_undifSed
Paleogene sedimentary rocks	sandstone	Olwb	Graded sandstone and mudstone with basal breccia; fining upward to mudstone	sandstone	15_undifSed
Paleogene sedimentary rocks	breccia	Olwbl	breccia and conglomerate with sandstone matrix	breccia	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Paleogene - Neogene sedimentary rocks	mudstone	Olwh	mudstone with graded limestone; breccia and sandstone interbeds	mudstone	15_undifSed
Paleogene sedimentary rocks	limestone	Olwi	graded bioclastic limestone interbedded with sandstone and mudstone	limestone	15_undifSed
Paleogene sedimentary rocks	sandstone	Olwk	Massive to graded sandstone with with weakly calcareous mudstone interbeds; rare conglomerate	sandstone	15_undifSed
Paleogene sedimentary rocks	sandstone	Olwk	fossiliferous sandstone with basal conglomerate; limestone lenses and shellbeds	marine sandstone	15_undifSed
Paleogene sedimentary rocks	conglomerate	Olwkc	Sandy pebble to cobble conglomerate with interbeds of minor coarse sandstone. Carbonaceous muddy sst & coalified wood near base	conglomerate	15_undifSed
Paleogene sedimentary rocks	conglomerate	Olwkc	Massive to bedded pebble to boulder conglomerate and breccia with scattered slump sheets; subordinate sandstone	conglomerate	15_undifSed
Paleogene sedimentary rocks	limestone	Olwkl	Sandy, graded, bioclastic limestone; calcareous sandstone; and breccia-bearing crystalline limestone	limestone	15_undifSed
Paleogene sedimentary rocks	sandstone	Olwu	Fining up sequence of graded sandstone	sandstone	15_undifSed
Paleogene sedimentary rocks	sandstone	Olwu	Fining up sequence of graded sandstone and mudstone; minor conglomerate, massive and laminated sandstone, & carbonaceous zst	sandstone	15_undifSed
Paleogene sedimentary rocks	sandstone	Olwu	Graded sandstone, laminated sandstone and mudstone, massive mudstone with rare graded limestone beds	sandstone	15_undifSed
Paleogene sedimentary rocks	conglomerate	Olwuc	Pebble to boulder conglomerate with minor pebbly to bouldery sandstone and carbonaceous mudstone & coal.	conglomerate	15_undifSed
Paleogene sedimentary rocks	limestone	Olza_	Pale, creamy, hard, siliceous, micritic limestone locally interbedded with siltstone, marl, sandstone, chert or greensand; local	undifferentiated Oligocene	15_undifSed
Paleogene - Neogene sedimentary rocks	mudstone	Om	Massive calcareous mudstone and siltstone sparsely fossiliferous	Cover	15_undifSed
Paleogene - Neogene sedimentary rocks	mudstone	Om	Massive calcareous mudstone and siltstone sparsely fossiliferous	Matiri Formation	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Paleogene - Neogene sedimentary rocks	mudstone	Om	Massive calcareous mudstone and siltstone, sparsely fossiliferous; thick limestone horizons	Matiri Formation	15_undifSed
Allochthonous rocks	mudstone	Om	Blue-grey to pale grey, calcareous mudstone and muddy limestone, glauconitic sandstone and minor siltstone and chert.	Motatau Group	15_undifSed
Allochthonous rocks	limestone	Om	Blue-grey to pale grey, calcareous mudstone to muddy limestone, commonly with glauconitic sandstone and minor interbedded siltst	Motatau Group	15_undifSed
Paleogene - Neogene sedimentary rocks	mudstone	Om	Massive calcareous mudstone; with inter-bedded calcareous sandstone and mudstone	Matiri Formation	15_undifSed
Basement (Western Province) metamorphic rocks	limestone	Oma	Black limestone lime mudstone with conodonts and sparse corals	Mount Arthur 2	18_crystalline
Allochthonous rocks	limestone	Omm	Blue-grey to white, micritic, coccolith foraminiferal, muddy limestone, commonly with thin glauconitic sandstone beds: commonly	Motatau Group	15_undifSed
Allochthonous rocks	limestone	Omm	Blue-grey to white, micritic, muddy limestone, commonly with glauconitic sandstone beds.	Motatau Group	15_undifSed
Allochthonous rocks	micrite	Omm	Micritic coccolith foraminiferal muddy limestone, commonly with redeposited beds of glauconitic sandstone.	Motatau Group	15_undifSed
Basement (Western Province) metamorphic rocks	schist	Omo	Biotite-muscovite schist metaquartzite bands	Onekaka Schist	18_crystalline
Allochthonous rocks	mudstone	Omp	Massive, white to grey, calcareous mudstone to siltstone with minor tuff.	Motatau Group	15_undifSed
Basement (Western Province) metamorphic rocks	schist	Omp	Biotite-muscovite-garnet-quartz schist metaquartzite bands	Pikikiruna Schist	18_crystalline
Basement (Western Province) metamorphic rocks	limestone	Oms	Grey limestone	Sluice Box Limestone	18_crystalline
Basement (Western Province) metamorphic rocks	limestone	Oms	Crystalline limestone and marble thin quartzite bands sparse corals and crinoids sandy limestone with conodonts	Arthur Marble 1	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Western Province) sedimentary rocks	shale	Omw	Dark shale with scattered quartzite beds	Alfred Formation	15_undifSed
Basement (Western Province) sedimentary rocks	argillite	Omw	Bedded siltstone calcareous siltstone quartz sandstone quartzite limestone bands	Wangapeka/Baldy Formation	15_undifSed
Paleogene sedimentary rocks	limestone	On	Crystalline to sandy limestone and calcareous mudstone and sandstone	Cover	15_undifSed
Paleogene sedimentary rocks	limestone	On	Limestone; predominantly shallow-water bioclastic varieties	Nile Group	15_undifSed
Paleogene - Neogene sedimentary rocks	limestone	On+mMbs	Limestone; predominantly shallow-water bioclastic varieties; and grey calcareous mudstone	Nile Group & Stillwater Mudstone	15_undifSed
Paleogene sedimentary rocks	limestone	Onc	Muddy micritic limestone	Cobden Limestone	15_undifSed
Paleogene - Neogene sedimentary rocks	limestone	Onl	Hard, glaucontic, sandy limestone. Mainly comprises Weka Pass Stone member	Weka Pass Stone	15_undifSed
Paleogene sedimentary rocks	mudstone	Onp	Grey-brown calcareous mudstone	Elizabeth Member	15_undifSed
Paleogene sedimentary rocks	sandstone	Oo	Pebbly quartzite; glauconitic sandstone; and minor thin siltstone beds		15_undifSed
Paleogene sedimentary rocks	conglomerate	Op	Conglomerate; coal measures; siltstone and limestone		15_undifSed
Basement (Western Province) metamorphic rocks	paragneiss	Opg	Undifferentiated biotite-garnet paragneiss		18_crystalline
Paleogene sedimentary rocks	limestone	Ot	Limestone, ranging from massive sandy to glauconitic and pebbly varieties through to pure flaggy bioclastic limestone, and thick		15_undifSed
Allochthonous rocks	sandstone	Ot	Calcareous sandstone, calcareous mudstone and limestone		15_undifSed
Paleogene sedimentary rocks	sandstone	Ot	Calcareous sandstone, calcareous mudstone and limestone		15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Paleogene sedimentary rocks	tuff	Ot	Carbonate-cemented basaltic bedded and agglomeratic tuff; associated feeder dikes, minor volcaniclastic sandstone	Thomas Formation	15_undifSed
Paleogene sedimentary rocks	siltstone	Ota	Calcareous sandy siltstone with interbedded concretionary sandstone and basal, cross-bedded or flaggy, glauconitic limestone.		15_undifSed
Paleogene sedimentary rocks	sandstone	Ota	Massive or banded, calcareous muddy sandstone and sandy calcareous siltstone, commonly glauconitic; basal, flaggy or cross bedde		15_undifSed
Paleogene sedimentary rocks	sandstone	Otg	Calcareous fine sandstone, siltstone and basal glauconitic, sandy limestone or greensand.		15_undifSed
Paleogene sedimentary rocks	sandstone	Otg	Massive, calcareous fine sandstone and siltstone with a basal flaggy glauconitic limestone or greensand.		15_undifSed
Paleogene sedimentary rocks	limestone	Oth	Flaggy limestone, calcareous siltstone, and carbonaceous siltstone and sandstone with thin coal seams and lenticular conglomerat		15_undifSed
Paleogene sedimentary rocks	siltstone	Oti	Massive, calcareous siltstone, commonly glauconitic, with rare, thin sandstone and muddy limestone beds; near basal sandy limest		15_undifSed
Paleogene sedimentary rocks	siltstone	Oti	Massive, glauconitic, calcareous siltstone, locally with a thin basal greensand.		15_undifSed
Paleogene sedimentary rocks	siltstone	Otl	Siltstone and sandstone with local limestone conglomerate and coal; calcareous in upper part.	lower Te Kuiti Subgroup	15_undifSed
Paleogene sedimentary rocks	siltstone	Otm	Massive siltstone and mudstone, with glauconitic, muddy sandstone beds; common siderite concretions near base.		15_undifSed
Paleogene sedimentary rocks	siltstone	Otm	Massive siltstone, mudstone and claystone, with interbedded glauconitic muddy fine sandstone.		15_undifSed
Paleogene - Neogene sedimentary rocks	limestone	Otn	Light-grey to white, flaggy, pure bioclastic limestone with local shell hash lenses.		15_undifSed
Paleogene sedimentary rocks	sandstone	Oto	Brown-grey, massive to poorly bedded, calcareous, muddy, glauconitic fine sandstone with scattered shells and shell fragments.		15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Paleogene sedimentary rocks	limestone	Otr	Limestone, ranging from massive sandy to glauconitic and pebbly varieties through to pure flaggy bioclastic limestone and thick		15_undifSed
Paleogene - Neogene sedimentary rocks	siltstone	Ott	Massive or weakly bedded, very calcareous sandy siltstone to silty fine-grained sandstone, locally with a sandy or muddy limesto		15_undifSed
Paleogene - Neogene sedimentary rocks	siltstone	Ott	Massive calcareous sandy siltstone to silty fine sandstone, locally with a thin basal muddy limestone.		15_undifSed
Paleogene - Neogene sedimentary rocks	limestone	Otu	Sandy and pure skeletal limestone with calcareous sandstone and rare conglomerate	upper Te Kuiti Group	15_undifSed
Allochthonous rocks	limestone	Otw	Stylolitic, bioclastic limestone with conglomerate and calcareous sandstone beds.		15_undifSed
Paleogene sedimentary rocks	limestone	Otw	Stylolitic, bioclastic limestone with conglomerate and calcareous sandstone beds.		15_undifSed
Paleogene sedimentary rocks	biosparite	Otw	Bryozoan-molluscan-echinoid-foraminiferal-algal limestone.		15_undifSed
Paleogene - Neogene igneous rocks	lamprophyre	Ov	Altered(carbonate) lamprophyric volc breccia w glass matrix & megacrysts; schist/mafic/ultramafic inclusions; lamprophyric dikes	lamprophyre diatreme	18_crystalline
Paleogene igneous rocks	olivine nephelinite	Ov	Olivine nephelinite plug at Mounseys Creek	Mounseys Creek plug	18_crystalline
Paleogene sedimentary rocks	sandstone	Ow	thin to thick bedded graded sandstone and mudstone, channelised conglomerate & breccia, rare olistoliths of limestone & basement	sandstone	15_undifSed
Paleogene sedimentary rocks	sandstone	Ow	Cross-bedded sst overlain by laminated muddy sst (Point Burn Fmn in SE), overlain by massive siltstone & sandstone (Stuart Fmn)	sandstone	15_undifSed
Paleogene sedimentary rocks	sandstone	Ow	Discontinuous basal mudstone; thin-bedded graded sandstone, upper part is massive siltstone/mudstone with lenticular massive sst	sandstone	15_undifSed
Paleogene sedimentary rocks	sandstone	Ow	Discontinous basal mudstone; thin-bedded graded sandstone; upper part is massive siltstone/mudstone with lenticular massive sst	sandstone	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Paleogene sedimentary rocks	sandstone	Ow	Massive and trough cross-bedded sandstone with interbeds of massive siltstone, overlain by graded sandstone	sandstone	15_undifSed
Paleogene sedimentary rocks	sandstone	Ow	Basal carbonaceous massive siltstone; massive or graded sandstone; x-bedded sandstone; zst/mst with discrete massive sst beds	sandstone	15_undifSed
Paleogene sedimentary rocks	sandstone	Ow	Arkosic massive sandstone (cross-bedded at base); usually calcareous; thin basal & higher breccia/conglomerate lenses; shellbeds	sandstone	15_undifSed
Paleogene sedimentary rocks	sandstone	Ow	sandstone, siltstone, pebbly sandstone, and conglomerate bands near lakes Fergus and Gunn; fossiliferous	sandstone	15_undifSed
Paleogene sedimentary rocks	sandstone	Ow	Arkosic massive sandstone (cross-bedded at base); usually calcareous; thin basal breccia/conglomerate lenses; shellbeds	sandstone	15_undifSed
Paleogene sedimentary rocks	sandstone	Owe	Thick- to thin-bedded graded sandstone and mudstone	flysch	15_undifSed
Paleogene sedimentary rocks	sandstone	Owt	Massive to graded lithic sandstone, thinner bedded & muddier up sequence; trough x-bedded sst member; rare conglomerate lenses	sandstone	15_undifSed
Paleogene sedimentary rocks	sandstone	Owt	Massive to graded lithic sandstone with minor mudstone and rare conglomerate, enclosing cross bedded sandstone	flysch	15_undifSed
Paleogene sedimentary rocks	sandstone	Owt	Massive to graded lithic sandstone with minor mst, increasingly thinner bedded & muddier up sequence; rare conglomerate lenses	sandstone	15_undifSed
Paleogene sedimentary rocks	sandstone	Owt	Graded, coarse grained sandstone with fining and thinning up cycles; interbedded calcareous mudstone. Dark grey mudstone at base	sandstone	15_undifSed
Paleogene sedimentary rocks	sandstone	PEe	Pale yellow-grey to green-grey quartz sandstone; medium to dark green-grey glauconitic quartz sands mainly near top	Early Tertiary marine sediment	15_undifSed
Paleogene sedimentary rocks	greensand	PEe	Glauconitic qtz sst(Hbush/Karetu) & calc, bentonitic, sandy mst(Ash) in upper part; greensand(Waip) & mica mst (Loburn) in lower	Early Tertiary marine sediments	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Paleogene sedimentary rocks	sandstone	PEe	Glauconitic qtz sst(Hbush/Karetu) & calc, bentonitic, sandy mst(Ash) in upper part; greensand(Waip) & mica mst (Loburn) in lower	Early Tertiary marine sediments	15_undifSed
Late Cretaceous - Paleogene sedimentary rocks	mudstone	PEe	Calcareous, bentonitic, sandy mst (Ashley Mst) in upper part; greensand (Waipara GS) and micaeous mst (Loburn Mst) in lower part	Early Tertiary marine sediments	15_undifSed
Paleogene sedimentary rocks	mudstone	PEe	Glauconitic qtz sst(Hbush/Karetu) & calc, bentonitic, sandy mst(Ash) in upper part; greensand(Waip) & mica mst (Loburn) in lower	Early Tertiary marine sediments	15_undifSed
Late Cretaceous - Paleogene sedimentary rocks	sandstone	PEe	Massive, light grey/yellow-brown, medium to fine, quartzose (qtz-cemented) sandstone; locally glauconitic with thin beds of mst	Charteris Bay Sandstone	15_undifSed
Late Cretaceous - Paleogene sedimentary rocks	sandstone	PEe	Marine, pale green, glauconitic quartzose sandstone, Broken River Formation sst & mst outcrops at eastern end	Charteris Bay Sandstone	15_undifSed
Late Cretaceous - Paleogene sedimentary rocks	sandstone	PEec	Pale yellow-grey to green-grey quartz sandstone; medium to dark green-grey glauconitic quartz sands mainly near top	Early Tertiary marine sediment	15_undifSed
Paleogene sedimentary rocks	limestone	PO	interbedded limestone and basaltic tuff, flows, breccia	Paleogene undifferentiated	15_undifSed
Paleogene sedimentary rocks	mudstone	PO	calc mst & sst interbedded w volcaniclastics(Tokakoriri);muddy lst & calcareous mst(Abbey); volc breccia & basalt flows(Otitia)	Paleogene undifferentiated	15_undifSed
Basement (Median Batholith) igneous rocks	granulite	PZKpm	Gneissic 2-pyroxene hornblende granulitic metadiorite & metagabbro cut by garnet-cpx reaction zones & amphibolitic shear zones	granulite	18_crystalline
Basement (Median Batholith) metamorphic rocks	orthogneiss	PZadvsp	weakly to strongly foliated fine biotite titanite allanite epidote granodioritic K feldspar megacrystic orthogneiss	orthogneiss	18_crystalline
Basement (Median Batholith) igneous rocks	granitoid	PZaio	Variably foliated qtz monzodiorite, diorite & tonalite cut by 2 generations of less deformed granitic dikes; metased rafts	granitoid	18_crystalline
Basement (Western Province) metamorphic rocks	gneiss	PZas	Variably mylonitic, gt quartzofeldspathic (ortho&para) to pelitic schist & gneiss. Minor hbl-bt gneiss, granite mylonite &marble	gneiss	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Western Province) metamorphic rocks	amphibolite	PZat	Amphibolitic mylonite & gneiss derived from metadiorite &gabbro. Minor calc-silicate, marble, psammitic schist &granite mylonite	amphibolite	18_crystalline
Basement (Western Province) metamorphic rocks	dunite	PZau	Dunite and harzburgite, variably serpentinised, and converted to mylonite	ultramafics	18_crystalline
Basement (Western Province) metamorphic rocks	calc-silicate	PZc	Massive to weakly foliated, cm-dm layered, metasandstone & calc-silicate with rare marble	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	metasandstone	PZc	Weakly foliated, cm-dm layered, metasandstone & metamudstone with subordinate calc-silicate, rare marble and metachert	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	psammite	PZc	Unfoliated to schistose psammitic, pelitic, calc-silicate and metavolcanic rocks with minor metaconglomerate, marble & quartzite	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	psammite	PZc	Unfoliated to schistose quartz-rich psammite with some pelite, migmatitic in places; lacks calc-silicates =?Fanny Bay Group	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	metavolcanics	PZck	Mafic and acidic metavolcanics & metavolcaniclastics, interbedded with psammite and rare marble & metaconglomerate	metavolcanics	18_crystalline
Basement (Western Province) metamorphic rocks	calc-silicate	PZcl	Interbedded cm-banded calc-silicate, calcic psammite, and thin marble with minor amphibolite and pelitic schist	calc-silicate	18_crystalline
Basement (Western Province) metamorphic rocks	marble	PZcma	Marble (up to 50 m thick) and minor calc-silicate	marble	18_crystalline
Basement (Western Province) metamorphic rocks	pelite	PZcp	Laminated pelitic schist interbedded with psammite, minor quartzite and quartzofeldspathic schist; often migmatitic	pelite	18_crystalline
Basement (Western Province) metamorphic rocks	psammite	PZcr	Biotite and calcic psammite with quartzite; minor pelitic schist, marble and calc-silicate	psammite	18_crystalline
Basement (Western Province) metamorphic rocks	psammite	PZcs	cm-dm bedded psammite locally interbedded with graphitic pelitic schist; minor calc-silicate, marble and rare quartzite	psammite	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Western Province) metamorphic rocks	psammite	PZcs	Psammite locally interbedded with graphitic pelitic schist; minor calc-silicate & marble; rare quartzite & basic metavolcanics	psammite	18_crystalline
Basement (Western Province) metamorphic rocks	schist	PZdcg	Thin to thick layered psammitic, pelitic & calc-psammitic schist; minor amphibolite & calc-silicate; rare quartzite & marble	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	amphibolite	PZdcg	Massive to banded amphibolite; minor metaconglomerate, psammite & pelite; rare serpentinite & hornblendite	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	gneiss	PZdcg	Banded-interlayered quartzofeldspathic, biot & hornblende gneiss; minor calc-silicate, marble, pelitic schist&orthogneiss sheets	metasediment	18_crystalline
Basement (Median Batholith) igneous rocks	quartz monzo-diorite	PZdg	Weakly foliated, locally banded, equigranular quartz monzodiorite & quartz diorite; subordinate diorite, gabbro & granodiorite	diorite	18_crystalline
Basement (Median Batholith) igneous rocks	quartz diorite	PZdi	Massive heterogeneous biotite-hornblende quartz diorite and mafic tonalite; locally contains gabbro enclaves	diorite	18_crystalline
Basement (Median Batholith) igneous rocks	diorite	PZdi	Massive, equigranular to heterogeneous hornblende diorite; subordinate hornblende gabbro, quartz diorite & quartz monzodiorite	diorite	18_crystalline
Basement (Median Batholith) igneous rocks	diorite	PZdi	Massive hornblende diorite and subordinate hornblende gabbro and quartz diorite	diorite	18_crystalline
Basement (Median Batholith) igneous rocks	granite	PZg	Strongly foliated medium-coarse grained K-feldspar megacrystic biotite±muscovite±garnet granite and granodiorite	granite	18_crystalline
Basement (Median Batholith) igneous rocks	granite	PZg	Bio±hornblende-bearing gneissic granite to monzonite, locally gradational into migmatitic metasediment; occurs as rafts in WFO	granite	18_crystalline
Basement (Median Batholith) igneous rocks	syenogranite	PZg	Leucocratic, coarse grained to megacrystic, strongly foliated, syenogranite & alkali feldspar granite raft in WFO	granite	18_crystalline
Basement (Median Batholith) igneous rocks	syenogranite	PZgbg	Coarse, K feldspar porphyritic biotite syenogranite. Contains rafts & xenoliths of Pleasant Pluton diorite & gabbro	granite	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Median Batholith) igneous rocks	granite	PZjlg	Medium-coarse grained, massive, equigranular biotite granite. Xenoliths of Pleasant Pluton diorite & gabbro and metasediments	granite	18_crystalline
Basement (Median Batholith) igneous rocks	diorite	PZkde	diorite and gabbro enclaves in various plutons	diorite	18_crystalline
Basement (Median Batholith) igneous rocks	granite	PZkosp	foliated fine to medium biotite muscovite garnet granite and granodiorite	granite pluton	18_crystalline
Basement (Median Batholith) igneous rocks	granite	PZku	granitoids forming islands off Stewart Island, mafic plutonics in Foveaux Strait islands and reefs	plutonics	18_crystalline
Basement (Western Province) metamorphic rocks	gneiss	PZlg	Massive to foliated amphibolite, garnet-hornblende-biot gneiss, quartzofeldspathic gneiss; rare calc-silicate gniess & psammite	gneiss	18_crystalline
Basement (Western Province) metamorphic rocks	paragneiss	PZlwp	Quartzofeldspathic gneiss, pelitic schist, bt-hbl gneiss, amphibolite,granitoid orthogneiss sheets,marble & calc-silicate gneiss	gneiss	18_crystalline
Basement (Western Province) metamorphic rocks	marble	PZma	Massive to thin banded marble & calc-silicate gneiss/schist, commonly intensely folded, minor quartzofeldspathic bands	marble	18_crystalline
Basement (Western Province) metamorphic rocks	paragneiss	PZmbg	Quartzofeldspathic gneiss &schist; minor biotite±hornblende schist,psammitic/pelite schist,quartzite;rare calc-silicate &marble	gneiss	18_crystalline
Basement (Western Province) metamorphic rocks	paragneiss	PZmbg	Biot, hornblende & quartzofeldspathic gneiss &schist; subordinate pelitic/psammitic schist &quartzite,rare calc-silicate &marble	gneiss	18_crystalline
Basement (Western Province) metamorphic rocks	schist	PZmbgb	Mafic fine grained biotite-plagioclase±hornblende schist; minor quartzofeldspathic schist and gneiss	schist	18_crystalline
Basement (Median Batholith) igneous rocks	granite	PZmg	Leucocratic, massive, equigranular, coarse grained 2 mica granite with enclaves of biotite tonalite	granite	18_crystalline
Basement (Western Province) metamorphic rocks	schist	PZmk	Pelitic &semi-pelitic schist; minor intercalated psammitic schist,quartzofeldspathic gneiss &quartzite;rare calc-silicate gneiss	schist	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Median Batholith) metamorphic rocks	amphibolite	PZmma	Amphibolitised layered mafic pluton of hornblende gabbro & gabbronorite, some troctolite, dunite & harzburgite;pelitic xenoliths	amphibolite	18_crystalline
Basement (Western Province) metamorphic rocks	pelite	PZmp	Weakly foliated pelite, commonly migmatitic, interlayered with often co-dominant quartzose psammite, rare calc-silicate	pelite	18_crystalline
Basement (Western Province) metamorphic rocks	schist	PZms	Psammitic schist interlayered with thin granitic orthogneiss towards Lake Macarthur	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	schist	PZms	Psammitic and amphibolitic schist and gneiss with minor calc-silicates; rare quartzite & pelitic rocks	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	paragneiss	PZms	Feldspathic gneiss with subordinate amphibolite, minor marble, calc-silicate and pelitic migmatitic schist	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	paragneiss	PZms	Massive to banded quartzofeldspathic, biot paragneiss &amphibolite; minor quartz-rich gneiss, mica schist, marble, calc-silicate	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	schist	PZms	Psammitic to pelitic biotite-muscovite-garnet quartzofeldspathic schist	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	schist	PZms	Psammitic biotite quartzofeldspathic schist	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	gneiss	PZms	Plagioclase-biotite gneiss and Plag-hornblende-biotite (amphibolitic) gneiss; minor thin quartzite & calc-silicate layers	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	schist	PZms	Variable mixture of psammitic, amphibolitic and pelitic schist; minor calc-silicates; rare marble	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	paragneiss	PZms	Quartzofeldspathic paragneiss with granodioritic and dioritic orthogneiss sheets; locally migmatitic	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	schist	PZms	Generally psammitic schists with subordinate amphibolites; minor calc-silicates & pelitic schist; rare marble	metasediment	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Western Province) metamorphic rocks	paragneiss	PZms	Quartzofeldspathic gneiss, psammitic & pelitic schist, & amphibolite; minor marble, calc-silicate & quartzite; orthogneiss sills	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	paragneiss	PZms	Massive to banded psammitic, quartzofeldspathic, amphibolitic & calc-silicate gneiss & schist; minor pelite, marble & quartzite	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	schist	PZms	Unsual mix pf porphyritic metadolerite with large plag laths and psammitic schist; rare psammite-pelite layers	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	schist	PZms	Psammitic and semi pelitic biotite schist; quartzofeldspathic gneiss-some of ortho origin & mylonitised towards Mt Watson Thrust	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	schist	PZms	Generally psammitic schist and amphibolite; minor calc-silicates & pelitic schist; rare marble	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	schist	PZms	Generally psammitic schists with subordinate amphibolites; minor calc-silicates, marble, pelitic schist and quartzite	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	amphibolite	PZmsa	Massive to banded amphibolite gneiss (hornblende-plagioclase±garnet); minor biotite±garnet gneiss; rare quartzite	amphibolite	18_crystalline
Basement (Western Province) metamorphic rocks	psammite	PZmsblp	Weakly foliated calcic psammitic gneiss, lacking hornblende; minor amphibolite and metaconglomerate; rare pelite	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	pelite	PZmsc	Partially migmatised, pelitic, biotite-quartz schist and gneiss; minor calc-silicate. Occurs as rafts in Mistake Diorite	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	gneiss	PZmsh	Porphyroblastic quartzofeldspathic biotite gneiss and biotite-epidote gneiss; minor amphibolitic schist	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	gneiss	PZmsh	Porphyroblastic quartzofeldspathic biotite gneiss and biotite-epidote gneiss; quartzofeldpathic garnet hornfels	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	amphibolite	PZmshe	Hornblende-epidote gneiss and biotite-bearing amphibolite	amphibolite	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Western Province) metamorphic rocks	psammite	PZmsl	Psammitic schist interlayered with amphibolitic±garnet schist of relatively low textural grade; minor marble & calc-silicates	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	psammite	PZmsl	Locally schistose, psammite and subordiante semi-pelitic rocks of low textural grade; minor marble, calc-silicates & amphibolite	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	paragneiss	PZmspp	Laminated & banded, fine-grained hornblende-biotite±garnet quartzofeldspathic gneiss; minor marble, quartzite & pelitic schist	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	paragneiss	PZmsq	Quartzose paragneiss with quartzofeldspathic psammitic to pelitic gneiss/schist; minor calc-silicates and amphibolite	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	psammite	PZmss	Quartzofeldspathic psammitic & subordinate semi-pelitc schist and gneiss; minor marble, calc-silicates, amphibolite & quartzite	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	psammite	PZmss	Weakly schistose, quartzofeldspathic psammite & subordinate semi-pelite; minor marble, calc-silicates, amphibolite & quartzite	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	psammite	PZmsst	Psammitic schist with subordinate pelitic schist, amphibolite, marble, calc-silicate & quartzite; pelites common in N of island	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	psammite	PZmsst	Quartzofeldspathic psammitic & subordinate semi-pelitc schist; minor marble, calc-silicates & quartzite	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	psammite	PZmsst	Quartzofeldspathic psammitic & subordinate semi-pelitc schist (locally gneissic); minor marble, calc-silicates & quartzite	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	psammite	PZmsst	Psammitic schist & gneiss interlayered with subordinate amphibolite; minor pelitic schist, marble, calc-silicate & quartzite	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	amphibolite	PZmv	Amphibolite with subordinate felsic(plag-biot±hbl) gneiss & psammitic quartzofeldspathic gneiss/schist; minor foliated granitoid	amphibolite	18_crystalline
Basement (Western Province) metamorphic rocks	amphibolite	PZmv	Amphibolite and felsic (plag-biot±hbl) schist/gneiss; subordinate quartzofeldspathic schist/gneiss; minor marble & calc-silicate	amphibolite	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Median Batholith) metamorphic rocks	orthogneiss	PZogt	Granodioritc and dioritic orthogniess intercalated with subordinate psammitic & pelitic schist; minor amphibolite & metagabbro	orthogneiss	18_crystalline
Basement (Median Batholith) igneous rocks	gabbro	PZpd	Fine to coarse grained, massive or rarely layered, pyroxene and hornblende diorite and gabbro; minor olivine gabbronorite	gabbro	18_crystalline
Basement (Median Batholith) igneous rocks	gabbronorite	PZpd	Fine to coarse grained, layered gabbronorite, gabbro & anorthosite; minor diorite in north of polygon with metasediment xenolith	gabbronorite	18_crystalline
Basement (Western Province) metamorphic rocks	psammite	PZsq	Micaceous psammitic schist interlayered with calc-silicate, quartzite & (semi-)pelitic schist; minor marble, QF & hbl gneiss	metasediment	18_crystalline
Basement (Median Batholith) igneous rocks	tonalite	PZst	Fine to medium grained, weakly foliated tonalite and minor granodiorite with abundant metasedimentary xenoliths	tonalite	18_crystalline
Late Cretaceous - Paleogene sedimentary rocks	sandstone	PaEe	Greenish, glauconitic sandstone, sandy mudstone, siltstone and quartzose sandstone.	Eyre Group	15_undifSed
Paleogene sedimentary rocks	limestone	PaEza	Pale, creamy, hard, siliceous, micritic limestone locally interbedded with siltstone, marl, sandstone, chert or greensand; local	Amuri Formation	15_undifSed
Paleogene sedimentary rocks	limestone	PaEzaOnw	Undifferentiated limestone, calcareous siltstone.	undiff. Amuri Limestone/Weka Pas	15_undifSed
Neogene sedimentary rocks	sandstone	Pad	Moderately to poorly consolidated, dune-bedded sandstone with minor parallel and ripple-laminated sandstone paleosols, lignite a		15_undifSed
Neogene sedimentary rocks	sand	Pad	Cemented dune sands and associated facies	cemented dune and interdune	09_beachBarDune
Neogene sedimentary rocks	sandstone	Pad	Cemented, dune-bedded sand and associated estuarine and fluviatile deposits.		15_undifSed
Neogene sedimentary rocks	sandstone	Pad	Moderately to poorly consolidated, cross-bedded, plane-parallel and ripple-laminated sandstone, with paleosols, lignite and carb		15_undifSed
Neogene sedimentary rocks	mudstone	Pal	Bioclastic limestone, massive sandstone and siltstone, and minor conglomerate		15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Neogene sedimentary rocks	siltstone	Pas	Poorly bedded sandstone and sandy siltstone in the Awatere Valley; and siltstone near White Bluffs	Starborough Formation	15_undifSed
Neogene sedimentary rocks	siltstone	Pas	poorly bedded sandstone and sandy siltstone in the Awatere Valley; and siltstone near White Bluffs		15_undifSed
Neogene sedimentary rocks	sandstone	Pat	Partly consolidated sandstone and mudstone of high terraces	higher alluvial terraces	16_terrace
Neogene sedimentary rocks	mudstone	Pau	Bioclastic limestone, sandstone, massive siltstone and minor conglomerate		15_undifSed
Neogene sedimentary rocks	mudstone	Pb	Massive brown calcareous mudstone minor sandstone limestone and coal seams	Cover	15_undifSed
Paleogene igneous rocks	basalt	Pb	Interbedded basalt flows and breccia; possibly Haumurian-Teurian Arnott Basalt; or Kaiatan-Runangan Otitia Basalt	Karangarua basalt	18_crystalline
Neogene sedimentary rocks	sandstone	Pbw	Fluviatile sandstone; estuarine mudstone and minor conglomerate		15_undifSed
Late Cretaceous - Paleogene sedimentary rocks	sandstone	Pe	Jarositic silty sst (Conway Fmn) overlain by glauconitic quartzose sandstone (Charteris Bay Sst). Marine	Conway Fmn/Charteris Bay Sst	15_undifSed
Late Cretaceous - Paleogene sedimentary rocks	sandstone	Pe	Jarositic concretionary silty sandstone (Conway Fmn) overlain by greensand (Waipara Greensand). Marine.	Conway Fmn/Waipara Greensand	15_undifSed
Late Cretaceous - Paleogene sedimentary rocks	sandstone	Pe	Jarositic concretionary silty sandstone (Conway Fmn) overlain by greensand (Wairpara Greensand). Marine.	Conway Fmn/Waipara Greensand	15_undifSed
Late Cretaceous - Paleogene sedimentary rocks	sandstone	Pe	Jarositic concretionary silty sst (Conway) with minor exposure of Broken River coal measures at base and 2 m greensand at top	Conway Fmn/Broken River Fmn	15_undifSed
Late Cretaceous - Paleogene sedimentary rocks	sandstone	Pe	Jarositic silty sst (Conway) overlain by interfingering greensand (Waipara) and glauconitic quartz sst (Charteris Bay). Marine	Conway/Waipara/Charteris Bay	15_undifSed
Paleogene sedimentary rocks	claystone	Pe_b	Carbonaceous and quartzose claystone mudstone and sandstone; local coal seams	Paleocene quartz coal measures	15_undifSed
Neogene sedimentary rocks	mudstone	Pea	massive, poorly bedded mudstone and minor alternating sandstone and mudstone		15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Neogene sedimentary rocks	mudstone	Pea	Pebbly or muddy greensand; calcareous mudstone; well sorted sandstone; concretionary mudstone; shelly coquina limestone		15_undifSed
Neogene sedimentary rocks	sandstone	Peah	marine and estuarine deposits	Onoke Group	15_undifSed
Neogene sedimentary rocks	coquina	Pek	barnacle grainstone	Kairakau Limestone	15_undifSed
Neogene sedimentary rocks	limestone	Pep	Poorly to well cemented shelly limestone; coquina and calcareous sandstone; and siltstone and sandy mudstone with minor grit		15_undifSed
Neogene sedimentary rocks	coquina	Pepc	shelly limestone and calcareous sandstone	Castlepoint Limestone	15_undifSed
Neogene sedimentary rocks	coquina	Pepn	limestone with aragonitic bivalves		15_undifSed
Neogene sedimentary rocks	coquina	Pept	limestone		15_undifSed
Neogene sedimentary rocks	coquina	Pepw	limestone		15_undifSed
Neogene sedimentary rocks	coquina	Per	barnacle grainstone	limestone member of the Makuri S	15_undifSed
Neogene sedimentary rocks	coquina	Perm	massive coarse sandy coquina limestone	limestone member of the Makuri S	15_undifSed
Neogene sedimentary rocks	coquina	Pet	limestone	Te Aute Limestone	15_undifSed
Neogene sedimentary rocks	sandstone	Pga	Repeated sequences of sandstone, siltstone, shellbeds and minor conglomerate		15_undifSed
Neogene sedimentary rocks	limestone	Pga	Repeated sequences of limestone, sandstone, mudstone and minor conglomerate		15_undifSed
Neogene sedimentary rocks	conglomerate	Ph	Poorly sorted and poorly bedded clay-bound greywacke gravel; minor sand; silt and clay		15_undifSed
Early Pleistocene river deposits	gravel	Ph	Clay bound gravel comprising greywacke and minor chert clasts	Cover	06_alluvium

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Neogene sedimentary rocks	conglomerate	Ph	weakly consolidated conglomerates; blue-grey laminated silty sand and mst; pebbly mst; 75% of congl clasts are Fiordland derived	Halfway Formation	15_undifSed
Neogene igneous rocks	ignimbrite	Pho	Welded, pumic-rich ignimbrite.		18_crystalline
Neogene sedimentary rocks	siltstone	Phr	Lacustrine siltstone, mudstone, tuffaceous sandstone and conglomerate.		15_undifSed
Allochthonous rocks	mudstone	Piw+Egw	see Waipawa & Wanstead Fms.		15_undifSed
Paleogene sedimentary rocks	mudstone	Piw-Ogw	see Waipawa , Wanstead & Weber Fms.		15_undifSed
Paleogene sedimentary rocks	mudstone	Piw-Ogw~	see Waipawa , Wanstead & Weber Fms.		15_undifSed
Neogene sedimentary rocks	sandstone	Pk	Pumiceous, shelly, calcareous sandstone, ovelain by pumiceous, carbonaceous sandstone with andesite and basalt pebbles, and orga		15_undifSed
Paleogene sedimentary rocks	sandstone	Pkf	Quartzo-feldspathic sandstones and pebbly conglomerates	Cover	15_undifSed
Neogene sedimentary rocks	gravel	Pl_k	Fluviatile gravel with clay silt and sand beds; mainly greywacke-derived; commonly brown-weathered; occasionally blue-grey	Plio-Pleistocene gravel	15_undifSed
Neogene sedimentary rocks	gravel	Pl_kc	Fluviatile gravel with clay silt and sand beds; mainly greywacke-derived; commonly brown-weathered; occasionally blue-grey	Plio-Pleistocene gravel	15_undifSed
Neogene sedimentary rocks	gravel	Pl_kg	Fluviatile gravel with clay silt and sand beds; mainly greywacke-derived; commonly brown-weathered; occasionally blue-grey	Plio-Pleistocene gravel	15_undifSed
Neogene river deposits	sandstone	Plal	Thin-bedded, carbonaceous sandstone and carbonaceous mudstone with intercalated conglomerate and lignite.	alluvium	06_alluvium
Neogene sedimentary rocks	sandstone	Plb	Light grey medium to fine sandstone; weak	Pliocene Mikonui sediment	15_undifSed
Neogene igneous rocks	andesite	Plco	Olivine pyroxene andesitic and basaltic dikes		18_crystalline
Neogene sedimentary rocks	sandstone	PleQa	sandstone siltstone and variably carboniferous mudstone with conglomerate lenses	sandstone	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Neogene sedimentary rocks	sandstone	PleQff	Conglomerate, sandstone, carbonaceous mudstone & minor lignite overlain by well-sorted, soft, fossiliferous sandstone & mudstone	sandstone	15_undifSed
Neogene sedimentary rocks	conglomerate	Plk	Torlesse-derived fluvial conglomerates interbedded with shallow marine sandstone and mudstone	Kowai Formation	05_fluvialEstuarine
Neogene sedimentary rocks	conglomerate	Plk	Brown-weathered greywacke-clast conglomerate w beds of sst, zst, mst, carbonaceous layers & shellbeds more common towards base	Kowai Formation	15_undifSed
Neogene sedimentary rocks	conglomerate	Plkc	Deformed weathered greywacke gravel with silt and sand beds; marine at base (Makikihi and Timaru)		15_undifSed
Neogene sedimentary rocks	conglomerate	Plke	Deformed weathered greywacke gravel with silt and sand beds		15_undifSed
Neogene sedimentary rocks	siltstone	Pln	Blue-grey fine sandy siltstone; mudstone; & minor debris-flow conglomerate	Greta Formation	15_undifSed
Neogene sedimentary rocks	siltstone	Plu	Blue-grey calcareous siltstone and sandstone with Torlesse-derived debris-flow conglomerate	Whanganui Siltstone	15_undifSed
Neogene sedimentary rocks	sandstone	Plwe	Thinly interbedded laminated siltstone & sandstone, locally cross-bedded; massive sandstone; minor shellbeds	sandstone	15_undifSed
Neogene sedimentary rocks	conglomerate	Plwec	Massive to m-bedded, sandy, clast supported, fine pebble to cobble conglomerate; rare macrofossils	conglomerate	15_undifSed
Neogene sedimentary rocks	sandstone	Pm	Pumiceous and non-pumiceous sanstone, mudstone, conglomerate and lignite		15_undifSed
Neogene sedimentary rocks	mudstone	Pm	Sandstone, mudstone, limestone shell beds, carbonaceous siltstone and lignite		15_undifSed
Neogene sedimentary rocks	sandstone	Pmtt	Alternating sandstone, limestone, siltstone and conglomerate		15_undifSed
Neogene sedimentary rocks	limestone	Pn	Coquina limestone and sandstone ranging from pebbly to well sorted		15_undifSed
Neogene sedimentary rocks	siltstone	Png	Fine-grained siltstone; poorly bedded marine, deltaic and terrestrial mudstone, sandstone and conglomerate	Greta Formation	15_undifSed
Paleogene sedimentary rocks	gravel	Po	Brown weathered greywacke granite schist conglomerate	Cover	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Cretaceous - Paleogene sedimentary rocks	siltstone	Pom	Marine quartzose and glauconitic sandstone and siltstone with shellbeds; nearshore to offshore environments; south of Waihemo FZ		15_undifSed
Paleogene sedimentary rocks	sandstone	Pom	quartzose and glauconitic sandstone siltstone shellbeds and limestone	marine sediments	15_undifSed
Neogene sedimentary rocks	gravel	Pom	Weathered gravel; with clasts predominantly of Torlesse sandstone or schist	Old Man Group	15_undifSed
Neogene sedimentary rocks	sandstone	Pomc	Glauconitic and feldspathic sandstone; thin coal seams; and fluvial conglomerate containing largely Torlesse clasts		05_fluvialEstuarine
Neogene igneous rocks	andesite	Poo	Coarse-grained, medium to high potassium, andesitic to dacitic intrusives (dikes, sills, plugs, necks and plutons).		18_crystalline
Neogene igneous rocks	andesite	Pop	Coarse-grained, medium to high potassium, andesitic to dacitic intrusives (dikes, sills, plugs, necks and plutons).		18_crystalline
Neogene igneous rocks	andesite	Pow	Coarse-grained, medium to high potassium, andesitic to dacitic intrusives (dikes, sills, plugs, necks and plutons).		18_crystalline
Neogene sedimentary rocks	mudstone	Pp	Massive mudstone, concretionary sandstone; limestone and conglomerate in the east		15_undifSed
Neogene sedimentary rocks	sandstone	Pp	Thin pebbly shell beds and massive, well sorted sandstone in the west, and massive silty mudstone in the east		15_undifSed
Neogene sedimentary rocks	sandstone	Pr	Sandstone, concretionary sandstone, mudstone, limestone, conglomerate		15_undifSed
Neogene sedimentary rocks	sandstone	Prm	Weakly bedded, bioturbated sandstone and siltstone		15_undifSed
Neogene sedimentary rocks	sandstone	Prm	Cross-bedded sandstone, siltstone and conglomerate		15_undifSed
Neogene sedimentary rocks	mudstone	Pro	Sandy to silty coquina limestone, and poorly-fossiliferous, bioturbated siltstone and sandstone	Orangipongo, Mangaonoho & Vinegar Hill formations	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Neogene sedimentary rocks	limestone	Pro	Alternating limestone, sandstone and siltstone		15_undifSed
Neogene sedimentary rocks	siltstone	Prt	Alternating siltstone, sandstone and limestone		15_undifSed
Neogene sedimentary rocks	mudstone	Prt	Sandy coquina limestone, poorly-fossiliferous, bioturbated massive siltstone and well sorted sandstone	Tikapu and Makohine formations	15_undifSed
Paleogene sedimentary rocks	sandstone	Pt	Graded bedded to massive sandstone; siltstone; calcareous bentonitic mudstone; and greensand		15_undifSed
Neogene sedimentary rocks	mudstone	Pt	Mudstone with concretionary sandstone		15_undifSed
Neogene sedimentary rocks	mudstone	Pt	Massive mudstone interbedded with well sorted, fine to medium, micaceous sandstone		15_undifSed
Neogene sedimentary rocks	gravel	Ptg	Terrestrial granitic-derived gravel sand and silt with carbonised wood. Laucustrine deposits with feldspathic clay and lignite	Cover	15_undifSed
Neogene sedimentary rocks	gravel	Ptg	Terrestrial granitic-derived gravel sand and silt with carbonised wood. Laucustrine deposits with feldspathic clay and lignite	Glenhope Gravel	15_undifSed
Paleogene sedimentary rocks	limestone	Ptm	Lenses of well bedded muddy limestone		15_undifSed
Neogene sedimentary rocks	gravel	Ptm	Poorly to moderately well sorted clay bound gravel containing up to boulder sized clasts of quartzofeldspathic sandstone	Cover	15_undifSed
Neogene sedimentary rocks	gravel	Ptm	Poorly to moderately well sorted clay bound gravel containing up to boulder sized clasts of greywacke	Moutere Gravel	15_undifSed
Neogene sedimentary rocks	gravel	Ptp	Poorly to moderately well sorted clay bound gravel	Cover	15_undifSed
Neogene sedimentary rocks	sandstone	Pu	Muddy, very fine sandstone		15_undifSed
Neogene sedimentary rocks	sandstone	Pu	Sandstone, concretionary sandstone and sandy mudstone		15_undifSed
Neogene sedimentary rocks	limestone	Puo	Conglomeratic limestone and sandstone	Omatane Limestone Member	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Neogene sedimentary rocks	sand	Pup	Pumiceous mud, sand and gravel with muddy peat and lignite: rhyolite pumice, including non-welded ignimbrite, tephra and alluvia		15_undifSed
Neogene sedimentary rocks	clay	Puw	Slightly pumiceous clays, with lignite, gravel and some pure pumice silt and sand.		15_undifSed
Pliocene igneous rocks	andesite	Pva	Andesite volcanics on offshore islands	(offshore islands)	18_crystalline
Neogene igneous rocks	basaltic andesite	Pvka	Cone-forming basaltic andesite flows.	Basaltic andesite	18_crystalline
Neogene igneous rocks	basalt	Pvkb	Basalt lava, volcanic plugs and minor tuff.	Basalt flows	18_crystalline
Neogene igneous rocks	breccia	Pvkh	Bedded hydrothermal breccia and siliceous sinter.	Sinter deposits	18_crystalline
Neogene igneous rocks	rhyolite	Pvkr	Alkaline and peralkaline rhyolite domes and local obsidian.	Rhyolite	18_crystalline
Neogene igneous rocks	scoria	Pvks	Basalt scoria.	Scoria	18_crystalline
Neogene igneous rocks	basalt	Pvlk	Basalt, basaltic andesite and andesite lava, tuffs and volcanic breccia; andesite dikes.		18_crystalline
Neogene igneous rocks	olivine basalt	Pvlo	Scoria, tuff and lava with compositions including basanite, alkali-olivene basalt and rare hawaiite; most lavas contain ultramaf		18_crystalline
Neogene igneous rocks	basalt	Pvlp	Basalt and basaltic andesite lava, volcanic breccia and tuffs.		18_crystalline
Neogene igneous rocks	basalt	Pvlt	Basalt and basaltic andesite lava with minor scoria and tuff.		18_crystalline
Neogene igneous rocks	basalt	Pvlu	Basalt lava and minor tuff.		18_crystalline
Neogene igneous rocks	rhyodacite	Pvw	Flow-banded rhyodacite lava.		18_crystalline
Neogene sedimentary rocks	sandstone	Pw	Repeated sequences of pebbly to well sorted sandstone, poorly fossiliferous siltstone and coquina shell beds		15_undifSed
Neogene sedimentary rocks	conglomerate	Pw	Poorly sorted and poorly bedded; channelised greywacke conglomerate		15_undifSed
Late Pleistocene - Holocene river deposits	gravel	Q1-2a	Generally unweathered; variable mixtures of gravel/sand/silt/clay forming low-level terraces or abandoned river plains	Young terrace/plain alluvium	16_terrace

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Pleistocene - Holocene shoreline deposits	gravel	Q1-2b	Well sorted gravel and sand on modern and abandoned post-glacial lake beaches	Lake beach gravel	09_beachBarDune
Late Pleistocene - Holocene river deposits	gravel	Q1-2f	Generally unweathered; variable mixtures of gravel/sand/silt forming slightly dissected alluvial fans; fan deltas beside lakes	Young alluvial fan	10_fan
Late Pleistocene - Holocene hill slope deposits	gravel	Q1-2s	Variable gravelly scree or colluvium deposits on >20 deg slopes; may merge with alluvial fans; may include minor glacial tills	Young slope deposit	14_moraineTill
Late Pleistocene - Holocene glacier deposits	gravel	Q1-2t	Unweathered bouldery till in cirques/rock glaciers; mixtures of gravel/sand/silt/clay; sharp moraine ridges; merges with scree	Young (late-glacial) till	14_moraineTill
Late Pleistocene - Holocene river deposits	gravel	Q1-4a	Unweathered to moderately weathered mixtures of gravel/sand/silt/clay underlying minor valley floors	Last Glacial stream alluvium	06_alluvium
Late Pleistocene - Holocene river deposits	gravel	Q1-4f	Generally unweathered; variable mixtures of gravel/sand/silt forming slightly dissected alluvial fans	Last Glacial alluvial fan	10_fan
Late Pleistocene - Holocene swamp deposits	peat	Q1-4p	Variable mixtures of peat/silt/sand associated with swamps	Last Glacial swamp sediment	01_peat
Late Pleistocene - Holocene hill slope deposits	gravel	Q1-4s	Variable gravelly scree or colluvium deposits on >20 deg slopes; may merge with alluvial fans; may include minor glacial tills	Last Glacial slope deposit	14_moraineTill
Middle Pleistocene - Holocene river deposits	gravel	Q1-6f	Variably weathered mixtures of gravel/sand/silt forming variably dissected/undissected alluvial fan complexes	Young-medium-age alluvial fan	10_fan
Middle Pleistocene river deposits	gravel	Q10a	Weathered gravel and sand in high alluvial terraces with minor loess	alluvium	06_alluvium
Middle Pleistocene river deposits	gravel	Q10a_om	Slightly to highly weathered mixtures of gravel/sand/silt/clay forming dissected terraces/plateaux	Medium-old glacial outwash	12_outwash
Middle Pleistocene river deposits	gravel	Q10af	Alluvial fan; scree; and colluvial deposits consisting of weathered poorly sorted gravels	fan deposits	10_fan
Middle Pleistocene river deposits	gravel	Q10af	moderately weathered sandy clayey gravel in fans	alluvial fan	10_fan

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Middle Pleistocene river deposits	gravel	Q10al	Weathered, poorly to moderately sorted gravel with minor sand and silt underlying eroded terraces; includes minor fan deposits a	Aldworth alluvial terrace deposits	16_terrace
Middle Pleistocene river deposits	gravel	Q10al	moderately weathered sandy clayey gravel	terrace alluvium	16_terrace
Middle Pleistocene river deposits	gravel	Q10al	Weathered gravel and loess deposits		06_alluvium
Middle Pleistocene river deposits	gravel	Q10al	River gravel and sand containing weathered clasts	alluvial deposits	06_alluvium
Middle Pleistocene river deposits	gravel	Q10al	River gravel and sand containing weathered clasts		06_alluvium
Middle Pleistocene river deposits	gravel	Q10ao	Slightly to moderately weathered, sandy to bouldery clayey gravel in outwash terrace remnants	outwash	12_outwash
Middle Pleistocene river deposits	gravel	Q10f	weathered gravel in high alluvial fans	fan	10_fan
Middle Pleistocene lahar deposits	debris	Q10he	Laharic breccia of andesite cobbles overlying sandstone and conglomerate beach deposits	Eltham Fm over Q11 beach deposits	09_beachBarDune
Middle Pleistocene lahar deposits	debris	Q10he	Laharic andesite breccia with mud, sand and lignite, buried by thick tephra deposits		15_undifSed
Middle Pleistocene hill slope deposits	breccia	Q10l	chaotic bouldery schist breccia landslide overlying outwash gravel in Kawarau Gorge	landslide	15_undifSed
Middle Pleistocene glacier deposits	gravel	Q10t	Till containing weathered clasts		14_moraineTill
Middle Pleistocene glacier deposits	gravel	Q10t	Till containing weathered clasts	glacial deposits	14_moraineTill
Middle Pleistocene glacier deposits	till	Q10t	slightly to moderately weathered boudery sandy gravel (till) in moraine remnants	till	14_moraineTill
Middle Pleistocene glacier deposits	gravel	Q10t_om	Slightly to highly weathered bouldery till; variable mixtures of gravel/sand/silt/clay in dissected moraine remnants	Medium-old till	14_moraineTill
Middle Pleistocene igneous rocks	rhyolite	Q10vor	rhyolite lava variably with lesser pumice and breccia as a carapace		18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Middle Pleistocene shoreline deposits	gravel	Q11b	Weathered bouldery sands to well-rounded and sorted gravels on marine bench remnants between 210 and 260m ASL	marine terrace deposit	16_terrace
Middle Pleistocene shoreline deposits	sand	Q11b	sand and gravel	marine terrace	16_terrace
Middle Pleistocene shoreline deposits	gravel	Q11b	Gravel, sand and mud		15_undifSed
Middle Pleistocene shoreline deposits	gravel	Q11b	Weathered bouldery sands to well-rounded and sorted gravels on marine bench remnants between 270 and 330m ASL	marine terrace deposit	16_terrace
Middle Pleistocene shoreline deposits	sand	Q11b	weathered sand and gravel loess	marine terrace deposits	16_terrace
Middle Pleistocene shoreline deposits	gravel	Q11b	Rangitatau terrace coverbreds comprising a range of shallow marine to paralic sediments.	Rangitatau marine terrace deposits	16_terrace
Middle Pleistocene igneous rocks	rhyolite	Q11vor	rhyolite lava variably with lesser pumice and breccia as a carapace		18_crystalline
Middle Pleistocene river deposits	gravel	Q12a	Weathered gravel and sand in high alluvial terraces	alluvium	06_alluvium
Middle Pleistocene river deposits	gravel	Q12af	locally derived slightly weathered sandy schist gravel	alluvial fan	10_fan
Middle Pleistocene river deposits	gravel	Q12afc	locally derived slightly weathered sandy schist gravel	alluvial fan	10_fan
Middle Pleistocene river deposits	gravel	Q12al	moderately weathered sandy gravel with minor clay	alluvium	06_alluvium
Middle Pleistocene river deposits	gravel	Q12ao	moderately weathered sandy gravel with minor clay and boulders	outwash	12_outwash
Middle Pleistocene lake deposits	silt	Q12k	moderately weathered laminated lake silt, sand, and clay with dropstones	lake sediments	08_lacustrine
Middle Pleistocene igneous rocks	rhyolite	Q12o	rhyolite lava variably with lesser pumice and breccia as a carapace		18_crystalline
Middle Pleistocene glacier deposits	till	Q12t	Till consisting of moderately weathered, poorly sorted, bouldery sandy gravel with silt lenses	till	14_moraineTill

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Middle Pleistocene shoreline deposits	gravel	Q13b	Weathered bouldery sands to well-rounded and sorted gravels on marine bench remnants between 360 and 380m ASL	marine terrace deposit	16_terrace
Middle Pleistocene shoreline deposits	gravel	Q13b	Weathered bouldery sands to well-rounded and sorted gravels on marine bench remnants between 425 and 460m ASL	marine terrace deposit	16_terrace
Middle Pleistocene shoreline deposits	gravel	Q13b	Ball terrace coverbreds comprising a range of shallow marine to paralic sediments.	Ball marine terrace deposits	16_terrace
Middle Pleistocene igneous rocks	rhyolite	Q13vr	rhyolite lava variably with lesser pumice and breccia as a carapace		18_crystalline
Early Pleistocene river deposits	gravel	Q14af	moderately weathered locally derived sandy schist-quartz gravel	alluvial fan	10_fan
Early Pleistocene igneous rocks	rhyolite	Q14vor	rhyolite lava variably with lesser pumice and breccia as a carapace		18_crystalline
Early Pleistocene shoreline deposits	gravel	Q15b	Weathered to strongly weathered boulders & sandy gravels mixed with peaty soils, overlie wave-cut platforms 500 & 550m ASL	marine terrace deposit	16_terrace
Early Pleistocene shoreline deposits	gravel	Q15b	Piri terrace coverbreds comprising a range of shallow marine to paralic sediments.	Piri marine terrace deposits	16_terrace
Early Pleistocene river deposits	gravel	Q16af	moderately weathered schist gravel in high fan remnants	alluvial fan	10_fan
Early Pleistocene river deposits	gravel	Q16ao	moderately weathered schist and greywacke gravel in terrace remnants	outwash	12_outwash
Early Pleistocene glacier deposits	till	Q16t	Till consisting of moderately weathered sandy gravel with minor silt; bouldery lag deposits in some places	till	14_moraineTill
Early Pleistocene shoreline deposits	gravel	Q17b	Marorau terrace coverbreds comprising a range of shallow marine to paralic sediments.	Marorau marine terrace deposits	16_terrace
Early Pleistocene shoreline deposits	gravel	Q17b	Weathered to strongly weathered boulders & sandy gravels mixed with peaty soils, overlie wave-cut platforms 600 & 640m ASL	marine terrace deposit	16_terrace
Early Pleistocene shoreline deposits	gravel	Q17b	Weathered to strongly weathered boulders & sandy gravels mixed with peaty soils, overlie wave-cut platforms 560 & 600m ASL	marine terrace deposit	16_terrace

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Holocene river deposits	gravel	Q1a	variably sorted fluvial gravels with silt lenses overlain by laminated carbonaceous silts 11kyrs. Overlies Q2 marine silt & sand	Young river alluvium	06_alluvium
Late Pleistocene - Holocene estuary, river and swamp deposits	sand	Q1a	Unconsolidated to poorly consolidated sand, peat, mud and shell deposits (estuarine, lacustrine, swamp, alluvial and colluvial).	estuarine, swamp and alluvial	15_undifSed
Holocene river deposits	gravel	Q1a	Modern river floodplain/low-level degradation tce. Unweathered, variably sorted gravel/sand/silt/clay. Surfaces <2 degree slope	Young terrace/plain alluvium	13_floodGravel
Holocene river deposits	gravel	Q1a	Gravel, sand and mud of modern and postglacial flood plains	alluvium	06_alluvium
Holocene river deposits	gravel	Q1a	Generally unweathered; variable mixtures of gravel/sand/silt/clay forming low-level terraces or abandoned river plains	Young terrace/plain alluvium	16_terrace
Holocene river deposits	gravel	Q1a	unweathered, variably sorted gravel/sand/silt/clay & minor peat of postglacial floodplains,may be terraced. Surface <2 deg slope	Young river alluvium	06_alluvium
Holocene river deposits	gravel	Q1a_af	Active flood plain. unweathered, rounded-subangular; variably sorted loose gravel/sand/mud. Assoc with surfaces <2 deg slope	Alluvium in active river bed	06_alluvium
Holocene river deposits	gravel	Q1a_af	Generally unweathered; variable loose gravel/sand/silt in active flood plains	Alluvium in active river bed	06_alluvium
Holocene river deposits	gravel	Q1a_af	Active flood plain. Unweathered; rounded-subangular; variably sorted loose gravel/sand/silt. Assoc with surfaces <2 deg. slope.	Alluvium in active river bed	06_alluvium
Late Pleistocene - Holocene river deposits	gravel	Q1a_wl	Generally unweathered; variable mixtures of gravel/sand/silt/clay forming low-level terraces or abandoned river plains	Young (late-glacial) outwash	12_outwash
Holocene river deposits	gravel	Q1ad	tabular foreset beds of unconsolidated gravel, sand, silt and minor peat in large active deltas	delta	06_alluvium
Holocene estuary deposits	sand	Q1ae	Sand, silt and mud of tidally influenced estuaries	Young estuarine deposit	05_fluvialEstuarine
Holocene estuary deposits	sand	Q1ae	Sand, silt and peat of lagoons and estuaries (Heathcote; Head of the Bay/Teddington)	Young estuarine deposit	05_fluvialEstuarine

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Holocene estuary deposits	silt	Q1ae	Estuarine deposits consisting of poorly consolidated silt; peat; sand and minor gravel	Estarine deposits	15_undifSed
Holocene estuary deposits	mud	Q1ae	Unconsolidated mud, sand and peat	estuarine deposits	05_fluvialEstuarine
Holocene estuary deposits	mud	Q1ae	Sand, silt mud and clay with local gravel and peat beds.	Estuarine deposits	05_fluvialEstuarine
Holocene estuary deposits	mud	Q1ae	unconsolidated peat, mud & sand	estuarine deposits	05_fluvialEstuarine
Holocene estuary deposits	mud	Q1ae	Unconsolidated to poorly consolidated mud, sand and peat of estuarine origin.	Estuarine deposits	05_fluvialEstuarine
Holocene estuary deposits	sand	Q1ae	Sand, silt and peat of lagoons and estuaries (Avon/Heathcote)	Young estuarine deposit	05_fluvialEstuarine
Holocene river deposits	gravel	Q1af	loose boulders, gravel sand and clay	alluvial fans	10_fan
Holocene river deposits	gravel	Q1af	loose, commonly angular, boulders, gravel, sand, and silt forming alluvial fans; grades into scree (upslope) & valley alluvium	alluvial fans	10_fan
Holocene river deposits	gravel	Q1af	Poorly sorted gravels forming alluvial fans screes and colluvial deposits	alluvial fan deposits	10_fan
Holocene river deposits	gravel	Q1af	Alluvial and colluvial fan deposits consisting of poorly sorted, poorly consolidated gravel, sand and clay	Holocene alluvial fan deposits	10_fan
Holocene river deposits	gravel	Q1af	Loose, commonly angular, boulders, gravel, sand & silt forming modern alluvial fans; may include debri flow & avalanche deposits	young alluvial fan	10_fan
Holocene river deposits	gravel	Q1af	Postglacial fan and scree deposits		06_alluvium
Holocene river deposits	gravel	Q1af	Structureless, bouldery deposits to sandy gravels of variable lithology.	Terrestial fan deposits	10_fan
Holocene river deposits	gravel	Q1af	poorly consolidated often poorly sorted fine to bouldery gravel with sand and mud	alluvial fan	10_fan
Holocene river deposits	gravel	Q1af	schist and greywacke gravel and sand in modern stream beds and flood plains	alluvial fans	06_alluvium

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Holocene river deposits	gravel	Q1af	Unconsolidated angular to sub-rounded boulders, cobbles and pebbles	Holocene alluvial fan deposits	10_fan
Holocene river deposits	gravel	Q1af	Alluvial fan; scree; and colluvial deposits consisting of poorly sorted gravels	fan deposits	10_fan
Holocene river deposits	gravel	Q1af	Alluvial fan; scree; and colluvial deposits consisting of poorly sorted gravels	Fan deposits	10_fan
Holocene river deposits	gravel	Q1af	Poorly sorted angular gravel, sand and mud.	alluvial fan	10_fan
Holocene lahar deposits	gravel	Q1afh	Gravel and sand, with common boulders, and intermixed andesitic tephra		15_undifSed
Holocene lahar deposits	gravel	Q1ah	Massive, poorly sorted, matrix supported gravel, sand and silt	undifferentiated Holocene debri*	15_undifSed
Holocene river deposits	sand	Q1ak	pumiceous sand, gravel and silt; derived predominantly from the Kaharoa Formation	Holocene alluvial fan deposits	10_fan
Holocene river deposits	gravel	Q1al	loose gravel sand silt and clay in modern flood plains and low terraces	valley alluvium	06_alluvium
Holocene river deposits	gravel	Q1al	unconsolidated gravel; sand and peat in modern stream beds; flood plains with minor overbank swamps	alluvium	06_alluvium
Holocene river deposits	gravel	Q1al	gravel, sand and silt	alluvial deposits	06_alluvium
Holocene river deposits	gravel	Q1al	unconsolidated gravel sand and peat in modern stream beds flood plains with minor overbank swamps	alluvium	06_alluvium
Holocene river deposits	gravel	Q1al	Poorly consolidated alluvial gravel, sand and mud	unweathered Holocene alluvium	06_alluvium
Holocene river deposits	gravel	Q1al	Postglacial river gravel and sand deposits		06_alluvium
Holocene river deposits	gravel	Q1al	loose well sorted sandstone- schist- and volcanic-derived gravel and sand often quartzose minor mud and peat	stream alluvium	06_alluvium
Late Pleistocene - Holocene river deposits	gravel	Q1al	sandy gravel in low terraces	alluvial terraces	16_terrace

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Holocene river deposits	gravel	Q1al	River gravel and sand, including modern river beds	alluvial deposits	06_alluvium
Holocene river deposits	gravel	Q1al	Well sorted gravels forming modern flood plains and young fan gravels	alluvial deposits	06_alluvium
Holocene river deposits	mud	Q1al	Alluvial and colluvial sand, silt, mud and clay with local gravel and peat beds.	Holocene alluvial and colluvial	06_alluvium
Holocene river deposits	gravel	Q1al	Well sorted floodplain gravels	Alluvial deposits	06_alluvium
Holocene river deposits	mud	Q1al	Unconsolidated to poorly consolidated mud, sand, gravel and peat deposits of alluvial, colluvial and lacustrine origins.	Alluvial/colluvial deposits	06_alluvium
Holocene river deposits	gravel	Q1al	Unweathered, loose, bouldery gravel, sand & mud in modern floodplains. Peat & carbonaceous mud bands may be interbedded	young alluvium	06_alluvium
Holocene river deposits	mud	Q1al	Sand, silt mud and clay with local gravel and peat beds.	Alluvial and colluvial deposits	06_alluvium
Holocene river deposits	gravel	Q1al	Alluvial gravel, sand, silt, mud and clay with local peat; includes modern river beds.	Holocene alluvium	06_alluvium
Holocene river deposits	gravel	Q1al	Unconsolidated gravel, sand, silt, clay, and minor peat of modern to postglacial flood plains, may be terraced	valley alluvium	06_alluvium
Holocene river deposits	mud	Q1al	Unconsolidated to poorly consolidated mud, sand, gravel and peat deposits of alluvial, colluvial and lacustrine origins.		06_alluvium
Holocene human-made deposits	gravel	Q1an	loose gravel and sand tailings from mining operations reclaimed land embankments and landfills	tailings reclamation and fill	04_fill
Holocene human-made deposits	gravel	Q1an	Highly angular fill removed from Manapouri tail race tunnels	anthropic deposit	04_fill
Holocene human-made deposits	gravel	Q1an	Landfill at Kate Valley	Anthropic deposits	04_fill
Holocene human-made deposits	gravel	Q1an	Engineered fill; reclaimed land (Bromley oxidation ponds); landfill (Burwood)	Anthropic deposits	04_fill
Holocene human-made deposits	gravel	Q1an	Engineered fill of reclaimed land (McCormack's Bay; Port of Lyttelton)	Anthropic deposits	04_fill

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Holocene human-made deposits	gravel	Q1an	Engineered fill of reclaimed land (McCormack's Bay;Port of Lyttelton)	Anthropic deposits	04_fill
Holocene human-made deposits	gravel	Q1an	Engineered fill of Lake Hood (Ashburton River)	Anthropic deposits	04_fill
Holocene swamp deposits	peat	Q1ap	poorly consolidated to firm interbedded mud and peat with minor sand inland peats lack sand	peat	01_peat
Holocene swamp deposits	silt	Q1as	Swamp deposits consisting of poorly consolidated silt; mud; peat and sand	Swamp deposits	15_undifSed
Holocene swamp deposits	mud	Q1as	Mud, peat.	swamp deposits	05_fluvialEstuarine
Holocene swamp deposits	peat	Q1as	Peat swamp deposits with interbedded sand, mud, & gravel; adjacent to alluvial floodplain gravels, and in swales between dunes	Young swamp deposit	01_peat
Holocene swamp deposits	peat	Q1as	peat in swamps and on actively growing peat mounds; with incursions of sand and silt	peat swamp	01_peat
Holocene swamp deposits	peat	Q1as	Soft, dark brown to black, mud, muddy sand, muddy peat and peat. Locally extensive peat bogs.	Swamp deposits and peat bogs	01_peat
Holocene swamp deposits	peat	Q1as	Swamp deposits consisting of poorly consolidated sand mud and peat	swamp deposits	01_peat
Holocene swamp deposits	peat	Q1as	Soft, dark brown to black, organic mud, muddy peat and woody peat with minor overbank sand, silt and mud.	Holocene swamp deposits and peat	01_peat
Holocene swamp deposits	silt	Q1as	Postglacial swamp deposits		15_undifSed
Holocene swamp deposits	peat	Q1as	Soft, dark brown to black, organic mud, muddy peat and woody peat.	Holocene swamp deposits and peat	01_peat
Holocene swamp deposits	peat	Q1as	Soft, dark brown to black, organic mud, muddy peat and woody peat with minor overbank sand, silt and mud.	swamp deposits	01_peat
Holocene swamp deposits	peat	Q1as	massive to bedded fibrous peat swamp deposits with interbedded sand, mud, and gravel	peat bog	01_peat
Holocene swamp deposits	peat	Q1as	Unconsolidated to poorly consolidated carbonaceous mud and peat of swamp origin.	Swamp deposits	01_peat

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Holocene swamp deposits	peat	Q1as_1al	Swamp deposits consisting of poorly consolidated sand mud and peat	swamp deposits	01_peat
Holocene river deposits	pumice	Q1at	Predominantly pumice sand, silt and gravel alluvium with charcoal fragments	Taupo Pumice alluvium	06_alluvium
Holocene river deposits	pumice	Q1at	Predominantly pumice sand, silt and gravel alluvium with charcoal fragments; derived from Taupo Pumice Formation	Taupo Pumice alluvium	06_alluvium
Holocene river deposits	pumice	Q1at	Pumice sand, silt and gravel alluvium		06_alluvium
Holocene river deposits	sand	Q1at	Pumice sand, silt and gravel with charcoal fragments.		06_alluvium
Holocene river deposits	pumice	Q1at	Predominantly pumice sand, silt and gravel alluvium with charcoal fragments.	Pumice alluvium	06_alluvium
Holocene igneous rocks	ignimbrite	Q1ati	Primary, non-welded ignimbrite and reworked deposits from the Taupo eruption. Includes Q1al alluvial gravel, sand and mud.	primary and reworked ignimbrite*	18_crystalline
Holocene igneous rocks	ignimbrite	Q1ati	Primary, non-welded ignimbrite and reworked deposits from the 181 AD Taupo eruption.	Primary and reworked ignimbrite	18_crystalline
Holocene igneous rocks	ignimbrite	Q1ati	Primary, non-welded ignimbrite and reworked deposits from the 1.7 ka BP Taupo eruption.	primary and reworked ignimbrite	18_crystalline
Holocene river deposits	sand	Q1atw	Gravely muddy sand; reworked Tarawera formation scoria and mud	Scoria alluvium	06_alluvium
Holocene river deposits	pumice	Q1aw	pumiceous sand, gravel and silt; predominantly derived from the Waiohau Formation	Pumice alluvium	06_alluvium
Holocene shoreline deposits	gravel	Q1b	Beach deposits consisting of marine gravel with sand; mud; and beach ridges	beach deposits	09_beachBarDune
Holocene shoreline deposits	gravel	Q1b	Unconsolidated, sandy to muddy, pebbly and shelly beach ridges.	Beach deposits	09_beachBarDune
Holocene shoreline deposits	sand	Q1b	sand and gravel in modern beaches; back-beach ridges and tidal platforms	beaches	09_beachBarDune
Holocene shoreline deposits	sand	Q1b	Unconsolidated marine gravel, sand and mud on modern beaches	Holocene beach deposits in coas*	09_beachBarDune

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Holocene shoreline deposits	sand	Q1b	loose boulders and sand on modern day marine terrace	marine bench	15_undifSed
Holocene shoreline deposits	sand	Q1b	uncemented sand and gravel near coast; seaward of inferred 6ky seacliff	beach	09_beachBarDune
Holocene shoreline deposits	gravel	Q1b	Loose, well sorted gravel and sand in modern beaches including post-glacial beaches above present lake level	young beach deposit	09_beachBarDune
Holocene shoreline deposits	sand	Q1b	sand	sand dune	09_beachBarDune
Holocene shoreline deposits	gravel	Q1b	beach deposits consisting of marine gravel, sand and mud on modern beaches	Holocene beach deposits	09_beachBarDune
Holocene shoreline deposits	gravel	Q1b	Loose, well sorted, gravel and sand in modern beaches	young beach deposit	09_beachBarDune
Holocene shoreline deposits	gravel	Q1b	Unweathered gravel, shingle and sand of former beaches and storm beach ridges	Young beach deposit	09_beachBarDune
Holocene shoreline deposits	sand	Q1b	loose well sorted sand deposited predominantly by marine and lesser aeolian processes minor gravel and silt	beach deposits	09_beachBarDune
Holocene shoreline deposits	gravel	Q1b	Unweathered well sorted gravel and sand with minor silt in modern or abandoned beach complexes	Young beach deposit	09_beachBarDune
Holocene shoreline deposits	sand	Q1b	Unweathered Holocene marine sand, gravel, and silt associated with modern beaches and estuaries	Young beach deposit	09_beachBarDune
Holocene shoreline deposits	sand	Q1b	Loose sand, gravel and shell underlying beaches and forming beach ridges and shell banks.	Beach deposits	09_beachBarDune
Holocene shoreline deposits	gravel	Q1b	sand and gravel	beach	09_beachBarDune
Holocene shoreline deposits	sand	Q1b	Loose, well sorted, gravel and sand in modern beaches	young beach deposit	09_beachBarDune
Holocene shoreline deposits	gravel	Q1b	Unweathered discoidal gravel, shingle, and sand in active beach with wind-deposited sand dunes behind it	Young beach deposit	09_beachBarDune
Holocene shoreline deposits	sand	Q1b	Beach deposits consisting of marine sand mud boulder banks	beach deposits	09_beachBarDune
Holocene shoreline deposits	sand	Q1b	Loose, well sorted gravel and sand in modern beaches including post-glacial beaches above present lake level	young beach deposit	09_beachBarDune

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Holocene shoreline deposits	sand	Q1b	Unweathered sand in bay head beach deposits	Young beach deposit	09_beachBarDune
Holocene shoreline deposits	gravel	Q1b	Unweathered gravel and sand of former beaches and storm beach ridges deposited at edges of sea or lake	Young beach deposit	09_beachBarDune
Holocene shoreline deposits	boulders	Q1b	bouldery lag on 6000 yr raised beach	marine bench	15_undifSed
Holocene shoreline deposits	sand	Q1b	Beach sand and gravel underlying present day coastal plain		15_undifSed
Holocene shoreline deposits	gravel	Q1b	Beach deposits consisting of marine gravel with sand; mud; and beach ridges	Beach deposits	09_beachBarDune
Holocene shoreline deposits	sand	Q1b	sand and gravel	beach	09_beachBarDune
Holocene shoreline deposits	gravel	Q1b-a	Unweathered discoidal gravel, shingle and sand in active beach and storm beach ridges	Active beach	09_beachBarDune
Holocene shoreline deposits	gravel	Q1bg	gravel in beach ridges on Tiwai peninsula	beaches	09_beachBarDune
Holocene lake deposits	gravel	Q1bk	well sorted, fresh, rounded, fine to medium gravels in benches and storm beach ridges around major lakes	beach gravel	09_beachBarDune
Holocene shoreline deposits	sand	Q1b~	sand and gravel	beach	09_beachBarDune
Holocene shoreline deposits	sand	Q1b~	sand	sand dune	09_beachBarDune
Holocene shoreline deposits	sand	Q1b~	loose well sorted sand deposited predominantly by marine and lesser aeolian processes minor gravel and silt	beach deposits	09_beachBarDune
Holocene windblown deposits	sand	Q1d	Dunes of unweathered wind-deposited beach sand, some pebbles and silt	Young dune deposit	11_loess
Holocene windblown deposits	sand	Q1d	Undifferentiated dunes and associated facies	Holocene dunes and associated local interdune swamps	11_loess
Holocene windblown deposits	sand	Q1d	Loose to consolidated garnet-rich sand in dune fields; minor peat	young dune deposits	11_loess

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Holocene windblown deposits	sand	Q1d	Undifferentiated dunes and associated facies	Holocene dunes and associated fa	11_loess
Holocene windblown deposits	sand	Q1d	Loose to consolidated hornblende-rich sand in dune fields; minor peat	young dune deposits	11_loess
Late Pleistocene shoreline deposits	gravel	Q1d	Conglomerate and bedded sand overlain by unconsolidated sand	Rakaupiko marine terrace deposits and overlying fixed dunes	09_beachBarDune
Holocene windblown deposits	sand	Q1d	Aeolian beach and andesitic sand deposited at the coast and Ruapehu ringplain	Holocene coastal dune sands and*	11_loess
Holocene windblown deposits	sand	Q1d	Loose to consolidated sand in dune fields; minor peat	young dune deposits	11_loess
Holocene windblown deposits	sand	Q1d	Sand dunes	dune deposits	11_loess
Holocene windblown deposits	sand	Q1d	Dunes of unweathered, wind-deposited river sand	Young dune deposit (river sand)	11_loess
Holocene windblown deposits	sand	Q1d	undifferentiated active and inactive dunes and estuarine deposits	sand dunes	11_loess
Holocene windblown deposits	sand	Q1d	Undifferentiated dunes and associated facies	Holocene dunes and associated lo	11_loess
Holocene windblown deposits	sand	Q1d	Dunesand		11_loess
Holocene windblown deposits	sand	Q1d	Loose to poorly consolidated, quartzofeldspathic and mafic-rich dune sands and associated facies.	Dunes and associated facies	11_loess
Holocene windblown deposits	sand	Q1d	Dunes of unweathered, wind-deposited beach sand	Young dune deposit (beach sand)	09_beachBarDune
Holocene windblown deposits	sand	Q1d-a	Active sand dunes; wind-deposited beach sand	Active dune (beach sand)	09_beachBarDune
Holocene windblown deposits	sand	Q1da	Loose sand in active unvegetated or sparsely vegetated dune fields and deflation zones.	Holocene mobile dunes	11_loess
Holocene windblown deposits	sand	Q1da	loose, hornblende-rich sand in active dune field	active dunes	11_loess

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Holocene windblown deposits	gravel	Q1da	Conglomerate and bedded sand overlain by loose sand	Rakaupiko marine terrace deposits and overlying mobile dunes	11_loess
Holocene windblown deposits	sand	Q1da	loose sand in active dune fields on West Coast	active dunes	11_loess
Holocene windblown deposits	sand	Q1df	Loose sand in arcuate, subparallel sand ridges, with rare, weakly developed covering paleosols.	Coastal foredunes	11_loess
Holocene windblown deposits	sand	Q1df	Loose sand in coastal foredunes	coastal foredunes	11_loess
Holocene windblown deposits	sand	Q1dm	loose well sorted sand and silt in mobile dune fields	mobile dunes	11_loess
Holocene windblown deposits	sand	Q1dm	Loose sand in active, unvegetated or sparsely vegetated dune fields and deflation zones.	Mobile dunes	11_loess
Holocene windblown deposits	sand	Q1dm	Loose sand in active unvegetated or sparsely vegetated dune fields and deflation zones.	Holocene mobile dunes	11_loess
Holocene windblown deposits	sand	Q1dm	Loose sand in mobile dunes.	Mobile dunes	11_loess
Holocene windblown deposits	sand	Q1dm	Active dunes	Active dunes	11_loess
Holocene windblown deposits	sand	Q1dm	Loose sand in mobile dunes	mobile dunes	11_loess
Holocene windblown deposits	sand	Q1dm	sand in active dune fields	active dunes	11_loess
Holocene windblown deposits	sand	Q1dp	Loose to poorly consolidated sand in fixed parabolic and local transverse dunes; minor sand, mud and peat in interdune deposits	Youngest parabolic and transvers	11_loess
Holocene windblown deposits	sand	Q1dp	Loose to poorly consolidated sand in fixed parabolic dunes. Interdune lake and swamp deposits.	fixed parabolic dunes	11_loess
Holocene windblown deposits	sand	Q1dp	Loose to poorly consolidated, quartzofeldspathic and mafic-rich sands in fixed parabolic dunes and local, small transverse dunes	Holocene fixed parabolic dunes	11_loess
Holocene windblown deposits	sand	Q1dp	Loose to poorly consolidated, quartzofeldspathic and mafic-rich sands in fixed parabolic dunes and local, small transverse dunes	Fixed parabolic dunes	11_loess

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Holocene windblown deposits	sand	Q1ds	stable longitudinal and parabolic sand dunes with peat in hollows	stable dunes	11_loess
Holocene windblown deposits	sand	Q1ds	loose well sorted sand and silt deposited mainly by aeolian processes may show dune forms	stable dunes	11_loess
Holocene windblown deposits	sand	Q1ds	Inactive dunes	Aeolian dunes	11_loess
Holocene windblown deposits	sand	Q1ds	loose to consolidated sand in stable dune fields; minor peat; garnet sand on Transit Beach	stable dunes	11_loess
Holocene igneous rocks	andesite	Q1ed	Pyroxene andesite and dacite lava flows, lava domes; volcanic breccia; some deposits contain amphibole		18_crystalline
Holocene river deposits	gravel	Q1f	Boulders, gravel, sand, silt and clay forming sloping alluvial fans and grading into scree and valley alluvium	fan	10_fan
Holocene river deposits	gravel	Q1f	Grey to brown, generally unweathered, mod-poorly sorted, silty subangular gravel & sand forming alluvial fans (slope 1-20deg)	Young alluvial fan	10_fan
Holocene river deposits	gravel	Q1f	Grey to brown, generally unweathered, silty subangular gravel & sand with minor peat in alluvial fans (slope 1-20deg)	Young alluvial fan	10_fan
Holocene river deposits	gravel	Q1f	Generally unweathered; variable mixtures of gravel/sand/silt forming alluvial fans (surface slope 1 to 20 deg)	Young or active alluvial fan	10_fan
Holocene river deposits	gravel	Q1f	mod-poorly sorted, silty, subang gravel & sand of alluvial fans; w large boulders from landslides & rockfalls in steep mountains	Young alluvial fan	10_fan
Holocene hill slope deposits	breccia	Q1h	Chaotic rock fragments in a sandy/silty matrix assoc with recent rock avalanche	Young rock avalanche deposit	15_undifSed
Holocene lahar deposits	gravel	Q1hh	Multiple beds of andesitic conglomerate and sand, some with broken tree trunks and branches, and pyroclastic flow deposits		15_undifSed
Holocene lahar deposits	breccia	Q1hk	Poorly sorted ouldery gravel, debris hyperconcentrated flow deposits, sand, silt, paleosol and peat	debris avalanche deposits at Ke*	15_undifSed
Holocene lahar deposits	debris	Q1hm	Laharic breccia including large (up to 35 m) andesite blocks in a muddy matrix		15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Holocene lahar deposits	gravel	Q1hn	Multiple beds of unconsolidated andesitic conglomerate and sand		15_undifSed
Holocene lahar deposits	debris	Q1hr	Laharic breccia of andesite cobbles and boulders in a muddy matrix		15_undifSed
Holocene lahar deposits	gravel	Q1ht	Multiple beds of unconsolidated andesitic conglomerate and sand		15_undifSed
Holocene lahar deposits	debris	Q1hu	Laharic breccia of andesite cobbles and boulders in a muddy matrix		15_undifSed
Holocene lahar deposits	debris	Q1hu	Laharic breccia of andesite cobbles with little or no tephra cover forming mounds	Opua Fm over Pungarehu Fm	15_undifSed
Holocene lahar deposits	debris	Q1hu	Bedded sands and conglomerate overlain by laharic andesite breccia with little tephra cover	Opua Fm over Warea Fm	15_undifSed
Holocene lake deposits	silt	Q1k	Sand; silt and mud in old lake deposits	lake deposits	08_lacustrine
Holocene lake deposits	sand	Q1k	Lucustrine silt, mud, sand & some peat around present and former lake shore (Lake Ellesmere)	Young lake deposit	08_lacustrine
Holocene lake deposits	silt	Q1k	Lake silts		08_lacustrine
Holocene lake deposits	sand	Q1k	Lucustrine silt, mud, sand & some peat around present and former lake shore (Lake Forsyth)	Young lake deposit	08_lacustrine
Holocene lake deposits	silt	Q1k	laminated micaceous silt, mud, and sand in old lake deposits	lake silt	08_lacustrine
Holocene igneous rocks	tephra	Q1kap	Crystal-rich biotite bearing rhyolite pumice fall and flow deposits		18_crystalline
Holocene igneous rocks	rhyolite	Q1kar	Crystal-rich biotite bearing rhyolite lava; variably with lesser pumice and breccia as a carapace		18_crystalline
Holocene hill slope deposits	breccia	Q1l	Landslide deposits ranging from coherent shattered masses of rock to unsorted angular rock fragments in a fine grained matrix	Landslide deposits	15_undifSed
Holocene hill slope deposits	debris	Q1l	Landslide and rockfall detritus, derived from more than one geological unit.	landslide and rockfall detritus	15_undifSed
Holocene hill slope deposits	breccia	Q1l	Chaotic unsorted debris in large landslides; debris consists of loose or cemented, clay to boulder breccia	landslide	15_undifSed
Holocene hill slope deposits	breccia	Q1l	Chaotic unsorted debris in landslide; mixture of lithological units	Young landslide deposit	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Holocene hill slope deposits	debris	Q1l		Landslide and rock fall detritus	15_undifSed
Holocene hill slope deposits	gravel	Q1l	Postglacial landslide debris		15_undifSed
Holocene hill slope deposits	boulders	Q1l	landslide deposits	landslide	15_undifSed
Holocene hill slope deposits	breccia	Q1l	Chaotic unsorted debris in rock fall; Lavericks Bay	Young landslide deposit	15_undifSed
Holocene hill slope deposits	boulders	Q1l	Earthflow deposits containing poorly sorted clasts up to boulder size in a clay matrix	landslide deposits	15_undifSed
Holocene hill slope deposits	boulders	Q1l_1al	Earthflow deposits containing poorly sorted clasts up to boulder size in a clay matrix	landslide deposits	15_undifSed
Holocene hill slope deposits	breccia	Q1ls	Deposit ranges from chaotic bouldery breccia in a gravel-sand-silt matrix to large semi-intact blocks of bedrock	young landslide deposit	15_undifSed
Holocene hill slope deposits	debris	Q1ls	Earthflow deposits containing poorly sorted clasts up to boulder size in a clay matrix	Landslide and rockfall detritus	15_undifSed
Holocene hill slope deposits	debris	Q1ls	Earthflow deposits containing poorly sorted clasts up to boulder size in a clay matrix	landslide and rockfall detritus	15_undifSed
Holocene hill slope deposits	breccia	Q1ls	ranges from shattered but relatively coherent rockslides to chaotic unsorted rock or soil debris in slumps & debri flow deposits	Young landslide deposit	15_undifSed
Holocene hill slope deposits	breccia	Q1ls	Debris of variable content; may include large rock/soil blocks/fragmental debris/plastic silt-clay; associated with landslides	Young landslide deposit	15_undifSed
Holocene hill slope deposits	breccia	Q1ls	Chaotic bouldery to muddy breccia in extensive landslide deposits	young landslide deposit	15_undifSed
Holocene hill slope deposits	debris	Q1ls	Earthflow deposits containing poorly sorted clasts up to boulder size in a clay matrix; at White Island and Waikaremoana	Landslide and rockfall detritus	15_undifSed
Holocene hill slope deposits	breccia	Q1ls_ra	Chaotic fragmental debris; variable content/texture; unit includes fall-out areas and debris <1m thick	Young rock avalanche deposit	15_undifSed
Holocene hill slope deposits	breccia	Q1ls_ra	Chaotic rock fragments in a sandy/silty matrix assoc with recent rock avalanche	Young rock avalanche deposit	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Holocene igneous rocks	tephra	Q1mkp	Rhyolite pumice tephra containing hornblende with minor clinopyroxene		18_crystalline
Holocene igneous rocks	rhyolite	Q1mkr	Rhyolite lava containing hornblende with minor clinopyroxene; variably with lesser pumice and breccia as a carapace		18_crystalline
Holocene human-made deposits	breccia	Q1n	Reclaimed land with fill consisting of domestic waste; sand; boulders and rock	Reclaimed land	04_fill
Holocene human-made deposits	gravel	Q1n	Material placed for hydroelectric and port works; dredge and mine tailings	anthropic (fill)	04_fill
Holocene human-made deposits	unknown	Q1n	Landfill areas containing recompacted clay- to gravel-sized materials, sometimes including demolition debris and refuse.	Construction fill	04_fill
Holocene human-made deposits	gravel	Q1n	unconsolidated sand and gravel in old mine workings; dredge tailings and sluicings	tailings	04_fill
Holocene human-made deposits	gravel	Q1n	Engineered fill associated with hydro-electric canals and dams; alluvial gold dredge tailings	Deposit of human origin	04_fill
Holocene human-made deposits	gravel	Q1n	Well sorted sandy quartz, schist & sandstone gravels in dredge tailings and sluicing deposits; anthromorphic fossils	tailings	04_fill
Holocene human-made deposits	breccia	Q1n	Semi-consolidated fill deposits consisting of sand, boulders and rock	Reclaimed land	04_fill
Holocene human-made deposits	gravel	Q1n	Dredge tailings; sluiced ground; and other man-made sediments		04_fill
Holocene human-made deposits	breccia	Q1n	Semi-consolidated fill deposits consisting of sand boulders and rock	Reclaimed land	04_fill
Holocene human-made deposits	fill	Q1nc	Landfill areas containing recompacted clay- to gravel-sized materials, sometimes including demolition debris.	Construction fill	04_fill
Holocene human-made deposits	breccia	Q1nc	Semi-consolidated fill deposits consisting of sand, boulders and rock	Reclaimed land	04_fill
Holocene human-made deposits	fill	Q1nm	Compacted mine waste in backfilled opencast pits and overburden landfill areas.	Mine waste	04_fill
Holocene human-made deposits	fill	Q1nr	Crushed and buried refuse in landfill areas.	Refuse landfill	04_fill

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Holocene swamp deposits	peat	Q1p	Variable mixtures of peat/silt/sand associated with swamps	Young swamp sediment	01_peat
Holocene swamp deposits	peat	Q1p	Silt and plant remains in lowland valley swamp settings	peat	01_peat
Holocene swamp deposits	peat	Q1p	Peat, silt and sand; in ponded area associated with active fault trace	Young swamp deposit	01_peat
Holocene swamp deposits	peat	Q1p	Massive to bedded fibrous peat swamp deposit with interbedded sand, mud, and gravel	peat bog	01_peat
Holocene swamp deposits	peat	Q1p	Peat, silt and sand; in swales between dunes and abandoned river channels	Young swamp deposit	01_peat
Holocene glacier deposits	gravel	Q1r	Rock glacier deposits in high alpine areas of the Kaikoura ranges	rock glacier	15_undifSed
Holocene igneous rocks	basalt	Q1rb	Basalt scoria beds		18_crystalline
Holocene igneous rocks	tephra	Q1rmp	Rhyolite pumice tephra containing hornblende, commmungtonite with minor clinopyroxene		18_crystalline
Holocene igneous rocks	rhyolite	Q1rmr	Rhyolite lava containing hornblende, commmungtonite with minor clinopyroxene; variably with lesser pumice and breccia as a cara*		18_crystalline
Holocene hill slope deposits	gravel	Q1s	Postglacial scree deposits		15_undifSed
Holocene hill slope deposits	gravel	Q1s	Variable gravelly scree or colluvium deposits on >20 deg slopes; may merge with alluvial fans; may include minor glacial tills	Young or active slope deposit	14_moraineTill
Holocene hill slope deposits	gravel	Q1s	Unconsolidated gravel and large boulders	Holocene scree deposits	15_undifSed
Holocene hill slope deposits	gravel	Q1s	angular unsorted sandy gravel forming loose scree and clay-bound slopewash	scree	15_undifSed
Holocene hill slope deposits	gravel	Q1s	angular, unsorted, loose sandy gravel forming active and inactive scree, colluvium, and clay-bound slopewash	scree	15_undifSed
Holocene hill slope deposits	gravel	Q1s	Angular, unsorted, blocky rock debris (scree) & variable mixtures of rock debris, sand, and silt (colluvium)	Young or active scree deposit	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Holocene hill slope deposits	gravel	Q1s	Angular unsorted gravelly scree and boulder flows	scree	15_undifSed
Holocene hill slope deposits	gravel	Q1s	Postglacial scree deposits	scree deposits	15_undifSed
Holocene hill slope deposits	gravel	Q1s	Angular, unsorted, loose, sandy to bouldery gravel in active to inactive scree, colluvium, & clay-bound slopewash	young scree deposit	15_undifSed
Holocene hill slope deposits	gravel	Q1s	Angular, unsorted, blocky rock debris (scree) derived from greywacke bedrock	Young or active scree deposit	15_undifSed
Holocene glacier deposits	till	Q1t	Unconsolidated, unweathered, angular, bouldery till; mixtures of gravel/sand/silt/clay; in cirque or upper valley moraines	young till deposit	14_moraineTill
Holocene glacier deposits	till	Q1t	Unweathered angular bouldery till; mixtures of gravel/sand/silt/clay; in well preserved cirque or upper valley moraines	till	14_moraineTill
Holocene glacier deposits	gravel	Q1t	Recent till		14_moraineTill
Holocene glacier deposits	till	Q1t	bouldery sandy till in moraines on Mt Anglem	moraine	14_moraineTill
Holocene glacier deposits	till	Q1t	Unweathered bouldery till; mixtures of gravel/sand/silt/clay; in mountain cirque moraines and some larger valleys	Young (Holocene) till	14_moraineTill
Holocene glacier deposits	till	Q1t	Unweathered, loose, angular bouldery till; mixtures of gravel/sand/silt/clay; mostly in moraine remnants of larger valleys	till	14_moraineTill
Holocene glacier deposits	gravel	Q1t	Recent till	glacial deposits	14_moraineTill
Holocene glacier deposits	gravel	Q1t	Unweathered bouldery till; mixtures of gravel/sand/silt/clay; in sharply defined moraines or rock glaciers; merges with scree	Young (Holocene) till	14_moraineTill
Holocene glacier deposits	gravel	Q1t_bh	Unweathered bouldery till; mixtures of gravel/sand/silt/clay; in sharply defined valley or cirque moraines	Young (late-glacial) till	14_moraineTill

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Holocene glacier deposits	till	Q1t_bh	Unweathered bouldery till; mixtures of gravel/sand/silt/clay; in sharply defined valley or cirque moraines	Young (late-glacial) till	14_moraineTill
Holocene glacier deposits	gravel	Q1t_lg	Unweathered bouldery till; mixtures of gravel/sand/silt/clay; in sharply defined valley or cirque moraines	Young (late-glacial) till	14_moraineTill
Holocene glacier deposits	gravel	Q1t_ls	Unweathered bouldery till; mixtures of gravel/sand/silt/clay; in sharply defined valley or cirque moraines	Young (late-glacial) till	14_moraineTill
Holocene glacier deposits	gravel	Q1t_tt	Unweathered bouldery till; mixtures of gravel/sand/silt/clay; in sharply defined valley or cirque moraines	Young (late-glacial) till	14_moraineTill
Holocene glacier deposits	gravel	Q1t_wl	Unweathered bouldery till; mixtures of gravel/sand/silt/clay; in sharply defined valley or cirque moraines	Young (late-glacial) till	14_moraineTill
Holocene igneous rocks	ignimbrite	Q1ta	Primary, non-welded ignimbrite and reworked deposits from the 181 AD Taupo eruption; very low density pumice	Primary and reworked ignimbrite	18_crystalline
Holocene igneous rocks	pyroclastic breccia	Q1tc	Scoriaceous and lithic andesitic fall deposits		18_crystalline
Holocene igneous rocks	andesite	Q1td1	Extensive, pressure-ribbed olivine andesite flows		18_crystalline
Holocene igneous rocks	andesite	Q1td2	Olivine andesite flows		18_crystalline
Holocene igneous rocks	basalt	Q1td3	Basalt lava flows and scoria	Red Crater Andesite and scoria	18_crystalline
Holocene igneous rocks	pyroclastic breccia	Q1tl	Basaltic andesite to dacite scoria, pumice, tephra and lithic clasts, and surge and fall deposits		18_crystalline
Holocene igneous rocks	andesite	Q1tm3	Andesite lava from lower Te Mari crater		18_crystalline
Holocene igneous rocks	andesite	Q1tm4	Andesite lava and scoria from upper Te Mari crater		18_crystalline
Holocene igneous rocks	andesite	Q1tn	Andesite to basaltic andesite lava, scoria and pyroclastic avalanche deposits flows from Ngauruhoe		18_crystalline
Holocene igneous rocks	mud	Q1twp	Scoriaceous lapilli and ash with variable mud; includes variable reworking as sands and gravels	Rotomahana mud and Tarawera scor	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Holocene igneous rocks	andesite lava	Q1vf	Multiple flows of andesite to basaltic-andesite lava and breccia	Fanthams Peak lava	09_beachBarDune
Holocene igneous rocks	andesite lava	Q1vl	Andesite lava forming cumulodomes	Undifferentiated Holocene andesite	18_crystalline
Holocene igneous rocks	gravel	Q1vm	Multiple beds of unconsolidated andesitic conglomerate and sand, with minor pyroclastic flow deposits		18_crystalline
Holocene igneous rocks	tephra	Q1vop	Rhyolite pumice tephra		18_crystalline
Holocene igneous rocks	andesite lava	Q1vpt	Multiple flows of hornblende andesite lava	Peters lava	18_crystalline
Holocene igneous rocks	andesite lava	Q1vsk	Multiple flows of andesitic to basaltic andesite lava	Skeet lava	18_crystalline
Holocene igneous rocks	andesite lava	Q1vst	Multiple flows of hornblende andesite lava	Staircase lava	18_crystalline
Holocene igneous rocks	andesite lava	Q1vsu	Multiple flows of andesitic to basaltic andesite lava	Summit lava	18_crystalline
Holocene igneous rocks	tephra	Q1vtp	Rhyolite pumice tephra		18_crystalline
Holocene igneous rocks	rhyolite	Q1vtr	Rhyolite lava; variably with lesser pumice and breccia as a carapace		18_crystalline
Holocene igneous rocks	andesite	Q1vw	undifferentiated Whakapapa Formation; valley-filling andesite flows, breccia and pyroclastic deposits		18_crystalline
Late Pleistocene - Holocene igneous rocks	andesite	Q1vwi	Whakapapa Formation; valley-filling andesite flows on NW flank of Mt Ruapehu		18_crystalline
Late Pleistocene - Holocene igneous rocks	andesite lava	Q1vwi	Dark grey, phenocryst-poor andesite lava and breccia		18_crystalline
Late Pleistocene - Holocene igneous rocks	andesite lava	Q1vwk	Multiple flows of hornblende andesite lava forming an older, partially eroded cone	Warwick lava	18_crystalline
Late Pleistocene - Holocene igneous rocks	andesite lava	Q1vwr	Dark grey, phenocryst-poor andesite lava and breccia		18_crystalline
Holocene igneous rocks	tephra	Q1wkp	Rhyolite pumice tephra containing hornblende and biotite with minor clinopyroxene		18_crystalline
Holocene igneous rocks	rhyolite	Q1wkr	Rhyolite lava containing hornblende, biotite with minor clinopyroxene; variably with lesser pumice and breccia as a carapace		18_crystalline
Late Pleistocene - Holocene river deposits	gravel	Q2-1a	Generally unweathered; variable mixtures of gravel/sand/silt/clay forming terraces	Latest Last Glacial alluvium	06_alluvium

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Pleistocene - Holocene river deposits	gravel	Q2-1f	Generally unweathered; variable mixtures of gravel/sand/silt forming alluvial fans (surface slope 1 to 20 deg)	Latest Last Glacial alluvial fan	10_fan
Late Pleistocene - Holocene glacier deposits	gravel	Q2-1t	Generally unweathered bouldery till; mixtures of gravel/sand/silt/clay; in well-defined valley moraines	Latest Last Glacial till	14_moraineTill
Late Pleistocene river deposits	gravel	Q2-3a	Generally unweathered; variable mixtures of gravel/sand/silt/clay forming terraces	Mid-late Last Glacial alluvium	06_alluvium
Late Pleistocene river deposits	gravel	Q2-4al	gravel, sand and silt	alluvial terraces	16_terrace
Late Pleistocene river deposits	gravel	Q2-4f	Variably weathered mixtures of gravel/sand/silt forming slightly to highly dissected alluvial fan complexes	Young-medium-age alluvial fan	10_fan
Middle Pleistocene - Late Pleistocene river deposits	gravel	Q2-6f	Variably weathered mixtures of gravel/sand/silt forming slightly to highly dissected alluvial fan complexes	Medium-age alluvial fan	10_fan
Late Pleistocene river deposits	gravel	Q2a	Generally unweathered; variable mixtures of gravel/sand/silt/clay forming extensive terraces or plains	Late Last Glacial alluvium	06_alluvium
Late Pleistocene river deposits	gravel	Q2a	Unweathered, brownish-grey, variable mix of gravels/sand/silt/clay in low river terraces; locally up to 2m silt (?loess) cap.	Late Last Glacial alluvium	06_alluvium
Late Pleistocene river deposits	gravel	Q2a	Generally unweathered,variably sorted gravel/sand/silt/clay & minor peat underlying low-medium level terraces,late Last Glacial	Late Last Glacial alluvium	06_alluvium
Late Pleistocene river deposits	gravel	Q2a_ac	Generally unweathered; variable mixtures of gravel/sand/silt/clay forming terraces	Late Last Glacial outwash	12_outwash
Late Pleistocene river deposits	gravel	Q2a_bf	Generally unweathered; variable mixtures of gravel/sand/silt/clay forming extensive terraces or plains	Late Last Glacial outwash	12_outwash
Late Pleistocene river deposits	gravel	Q2a_em	Generally unweathered; variable mixtures of gravel/sand/silt/clay forming extensive terraces or plains	Late Last Glacial outwash	12_outwash
Late Pleistocene river deposits	gravel	Q2a_hk	Generally unweathered; variable mixtures of gravel/sand/silt/clay forming extensive terraces or plains	Late Last Glacial outwash	12_outwash

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Pleistocene river deposits	gravel	Q2a__js	Generally unweathered; variable mixtures of gravel/sand/silt/clay forming extensive terraces or plains	Late Last Glacial outwash	12_outwash
Late Pleistocene river deposits	gravel	Q2a__la	Generally unweathered; variable mixtures of gravel/sand/silt/clay forming extensive terraces or plains	Late Last Glacial outwash	12_outwash
Late Pleistocene river deposits	gravel	Q2a__lh	Generally unweathered; variable mixtures of gravel/sand/silt/clay forming terraces	Late Last Glacial outwash	12_outwash
Late Pleistocene river deposits	gravel	Q2a__mj	Generally unweathered; variable mixtures of gravel/sand/silt/clay forming extensive terraces or plains	Late Last Glacial outwash	12_outwash
Late Pleistocene river deposits	gravel	Q2a__mn	Generally unweathered; variable mixtures of gravel/sand/silt/clay forming extensive terraces or plains	Late Last Glacial outwash	12_outwash
Late Pleistocene river deposits	gravel	Q2a__sl	Generally unweathered; variable mixtures of gravel/sand/silt/clay forming terraces	Late Last Glacial outwash	12_outwash
Late Pleistocene river deposits	gravel	Q2a__tc	Generally unweathered; variable mixtures of gravel/sand/silt/clay forming extensive terraces or plains	Late Last Glacial outwash	12_outwash
Late Pleistocene river deposits	gravel	Q2a__tk	Generally unweathered; variable mixtures of gravel/sand/silt/clay forming extensive terraces or plains	Late Last Glacial outwash	12_outwash
Late Pleistocene river deposits	gravel	Q2a__tr	Generally unweathered; variable mixtures of gravel/sand/silt/clay forming extensive terraces or plains	Late Last Glacial outwash	12_outwash
Late Pleistocene river deposits	gravel	Q2af	Fresh to weakly weathered gravel and sand in gently sloping alluvial fan deposit	Late Last Glacial alluvial fan	10_fan
Late Pleistocene river deposits	gravel	Q2af	Poorly sorted steep fan gravel deposits	fan deposits	10_fan
Late Pleistocene river deposits	gravel	Q2af	sandstone gravel and sand in piedmont fans	alluvial fans	10_fan
Late Pleistocene river deposits	gravel	Q2af	poorly consolidated and sorted slightly weathered fine to bouldery sandstone- or gravel sand and mud	alluvial fan	10_fan
Late Pleistocene river deposits	gravel	Q2af	River gravel and sand; and fan deposits		06_alluvium

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Pleistocene river deposits	gravel	Q2af	Alluvial and colluvial fan deposits consisting of poorly sorted, weakly consolidated gravel, sand, clay and loess	Ohakea alluvial and colluvial f*	06_alluvium
Late Pleistocene river deposits	gravel	Q2af	Clay bound poorly sorted gravels forming alluvial fans and colluvial deposits	alluvial fan deposits	10_fan
Late Pleistocene river deposits	gravel	Q2af	Alluvial and colluvial fan deposits consisting of poorly sorted, weakly consolidated gravel, sand, clay and loess	Ohakean alluvial and colluvial f	06_alluvium
Late Pleistocene river deposits	gravel	Q2af	Poorly sorted steep fan gravel deposits	Fan deposits	10_fan
Late Pleistocene river deposits	gravel	Q2af	unweathered to slightly weathered, sandy to silty, locally derived schist gravel in alluvial fans	alluvial fan	10_fan
Late Pleistocene river deposits	gravel	Q2af	Alluvial and colluvial fan deposits consisting of poorly sorted, weakly consolidated gravel, sand, clay and loess	Ohakean alluvial, colluvial fans	10_fan
Late Pleistocene - Holocene river deposits	gravel	Q2af-Q1af	Alluvial fan; scree; and colluvial deposits consisting of poorly sorted gravels	fan deposits	10_fan
Late Pleistocene - Holocene river deposits	gravel	Q2af_1al	Poorly sorted steep fan gravel deposits	fan deposits	10_fan
Late Pleistocene river deposits	gravel	Q2af_4af	Poorly sorted steep fan gravel deposits	fan deposits	10_fan
Late Pleistocene river deposits	sand	Q2ah	Cross-bedded pumice sand, silt and gravel with interbedded peat.		06_alluvium
Late Pleistocene river deposits	gravel	Q2al	River gravel and sand deposits		06_alluvium
Late Pleistocene river deposits	gravel	Q2al	greywacke gravel and sand overlain by loess	alluvium	06_alluvium
Late Pleistocene river deposits	gravel	Q2al	bedded, locally derived, unweathered to slightly weathered sandy gravel in low terraces in non-glaciated catchments	alluvium	06_alluvium
Late Pleistocene river deposits	sand	Q2al	Cross-bedded pumice sand, silt and gravel with interbedded peat		06_alluvium

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Pleistocene river deposits	gravel	Q2al	Poorly to moderately sorted gravel with minor sand or silt underlying terraces; includes minor fan gravel	Alluvial deposits	06_alluvium
Late Pleistocene river deposits	gravel	Q2al	sandy greywacke gravel overlain by loess; schist-greywacke-quartz sandy gravel in the Clutha catchment	alluvial terraces	16_terrace
Late Pleistocene river deposits	gravel	Q2al	River gravel and sand		06_alluvium
Late Pleistocene river deposits	gravel	Q2al	poorly to moderately sorted gravel with minor sand or silt underlying terraces	alluvium	06_alluvium
Late Pleistocene river deposits	mud	Q2al	Locally derived lacustrine mud, silt, gravel and peat.	Late Pleistocene lake sediments	06_alluvium
Late Pleistocene river deposits	gravel	Q2al	sandy greywacke gravel overlain by loess	alluvial terraces	16_terrace
Late Pleistocene - Holocene river deposits	gravel	Q2al	sandy gravel in low terraces	alluvial terraces	16_terrace
Late Pleistocene river deposits	gravel	Q2al	Poorly to moderately sorted gravel with minor sand and silt underlying terraces; includes minor fan deposits and loess	Ohakea alluvial terrace deposits	16_terrace
Late Pleistocene river deposits	gravel	Q2al	poorly consolidated slightly weathered sandy quartz-schist- or volcaniclastic-derived gravel and sand	terrace alluvium	16_terrace
Late Pleistocene river deposits	gravel	Q2al	Clay bound gravels and minor fan deposits forming lowest aggradation surfaces above major rivers	alluvial deposits	06_alluvium
Late Pleistocene - Holocene river deposits	sand	Q2al	variably weathered and degraded sand and gravel with interbedded peat in alluvial flats and terraces	alluvial terraces	16_terrace
Late Pleistocene river deposits	gravel	Q2al	Gravel, sand and silt of low river terraces	alluvium	06_alluvium
Late Pleistocene river deposits	gravel	Q2al	sandy gravel in low terraces	alluvial terraces	16_terrace
Late Pleistocene river deposits	gravel	Q2al	Poorly to moderately sorted gravel with minor sand or silt underlying terraces; includes minor fan gravel	alluvial deposits	06_alluvium
Late Pleistocene river deposits	gravel	Q2al	sandy gravel in outwash and alluvial terraces	alluvial terraces	16_terrace

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Pleistocene - Holocene river deposits	gravel	Q2al	sandy greywacke gravel overlain by loess; schist-greywacke-quartz sandy gravel in the Clutha catchment	alluvial terraces	16_terrace
Late Pleistocene river deposits	gravel	Q2al	Unweathered, loose gravels, sand, and mud in low terraces	Late Last Glacial alluvium	06_alluvium
Late Pleistocene river deposits	gravel	Q2al	Unweathered to slightly weathered, loose, bouldery gravel, sand & mud in low aggradational and degradational terraces	Late Last Glacial alluvium	06_alluvium
Late Pleistocene river deposits	gravel	Q2al	Q2 degradation surface cut into silty to sandy gravel of Q4 White Burn Formation outwash	alluvium	06_alluvium
Late Pleistocene river deposits	gravel	Q2al	Gravel, sand and silt.	alluvial terrace deposits	16_terrace
Late Pleistocene - Holocene river deposits	gravel	Q2al_1al	Poorly to moderately sorted gravel with minor sand or silt underlying terraces, includes minor fan gr	alluvial deposits	06_alluvium
Late Pleistocene river deposits	gravel	Q2al_2af	Poorly to moderately sorted gravel with minor sand or silt underlying terraces; includes minor fan gravel	alluvial deposits	06_alluvium
Late Pleistocene river deposits	gravel	Q2ao	Unweathered to slightly weathered, loose sandy gravel usually on large outwash plains; basal lag on degraded surfaces	Late Last Glacial outwash	12_outwash
Late Pleistocene river deposits	gravel	Q2ao	sandy to bouldery outwash gravels	outwash gravel	12_outwash
Late Pleistocene river deposits	gravel	Q2ao	Generally unweathered, well-sorted, loose, sandy to bouldery gravel forming large terraces and outwash plains	Late Last Glacial outwash	12_outwash
Late Pleistocene river deposits	gravel	Q2ao	generally unweathered, well sorted, loose, sandy to bouldery gravel forming large terraces and outwash plains	outwash	12_outwash
Late Pleistocene river deposits	gravel	Q2ao	Generally unweathered, well sorted, loose, sandy to bouldery gravel forming large terraces and outwash plains	Late Last Glacial outwash	12_outwash
Late Pleistocene river deposits	gravel	Q2aob	Generally unweathered, brownish-grey, variable mix of gravel/sand/silt/clay outwash deposited during early-mid LGM	Early-mid LGM outwash	12_outwash

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Pleistocene river deposits	gravel	Q2aoe	Unweathered to slightly weathered, loose sandy gravel usually on large outwash plains; often with basal lag	outwash	12_outwash
Late Pleistocene river deposits	gravel	Q2aoe	Unweathered to slightly weathered, loose, well rounded, sandy to silty gravel usually on large outwash plains	outwash	12_outwash
Late Pleistocene river deposits	gravel	Q2aoe	Unweathered to slightly weathered, loose sandy gravel usually on large outwash plains; often with basal lag	Late Last Glacial outwash	12_outwash
Late Pleistocene river deposits	gravel	Q2aoh	Unweathered to slightly weathered, well sorted, sandy gravel forming large outwash terraces in Clutha catchment	outwash	12_outwash
Late Pleistocene river deposits	gravel	Q2aome	Unweathered to slightly weathered, well sorted, sandy gravel forming large outwash terraces in Clutha catchment	outwash	12_outwash
Late Pleistocene river deposits	gravel	Q2aop	Generally unweathered, brownish-grey, variable mix of gravel/sand/silt/clay outwash deposited during late Last Glacial Maximum	Late LGM outwash	12_outwash
Late Pleistocene swamp deposits	peat	Q2as	Swamp deposits consisting of peat; sand and mud	Swamp deposits	01_peat
Late Pleistocene windblown deposits	sand	Q2d	Dunes of slightly weathered wind-deposited river sand	Late Last Glacial dune	11_loess
Late Pleistocene river deposits	gravel	Q2f	Generally unweathered, silty subangular gravel & sand forming alluvial fans (surface slope 1-20deg); minor gully dissection	Late Last Glacial alluvial fan	10_fan
Late Pleistocene river deposits	gravel	Q2f	Boulders, gravel, sand and clay forming sloping low alluvial fans	fan	10_fan
Late Pleistocene river deposits	gravel	Q2f	Generally unweathered; variable mixtures of gravel/sand/silt forming alluvial fans (surface slope 1 to 20 deg)	Late Last Glacial alluvial fan	10_fan
Late Pleistocene river deposits	gravel	Q2f_mn	Generally unweathered; variable mixtures of gravel/sand/silt forming alluvial fans (surface slope 1 to 20 deg)	Late Last Glacial alluvial fan	10_fan
Late Pleistocene lahar deposits	debris	Q2hp	Laharic breccia of andesite cobbles overlain in places by ashy bedded sands and conglomerate	Warea Fm over Pungarehu Fm	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Pleistocene lahar deposits	debris	Q2hp	Laharic breccia of andesite cobbles and boulders in a muddy matrix		15_undifSed
Late Pleistocene lahar deposits	debris	Q2hr	Laharic breccia of andesite cobbles overlain in places by ashy bedded sands and conglomerate	Warea Fm over Ngaere Fm	15_undifSed
Late Pleistocene lahar deposits	gravel	Q2hr	Multiple beds of indurated to poorly consolidated andesitic conglomerate and sand		15_undifSed
Late Pleistocene lahar deposits	gravel	Q2ht	Massive to well bedded andesitic gravel and sand, and minor debris deposits	Undifferentiated Late Quaternary lahars (Ruapehu)	15_undifSed
Late Pleistocene lake deposits	gravel	Q2k	Fluvioglacial material reworked by wind and waves at edges of former Glacial Lake Speight	Late LGM lake beach	09_beachBarDune
Late Pleistocene hill slope deposits	breccia	Q2ls_ra	Chaotic fragmental debris; variable content/texture; unit includes fall-out areas and debris <1m thick	Young landslide deposit	15_undifSed
Late Pleistocene river deposits	gravel	Q2o	loose gravel; sand; silt and clay forming outwash plains and traceable upstream to moraine	outwash	12_outwash
Late Pleistocene igneous rocks	rhyolite	Q2okr	Rhyolite lava with trace hornblende, biotite in some phases; variably with lesser pumice and breccia as a carapace		18_crystalline
Late Pleistocene igneous rocks	andesite	Q2pk	Dark, olivine andesite flows, scoria, lapilli and ash		18_crystalline
Late Pleistocene igneous rocks	tephra	Q2rep	Rhyolite pumice tephra containing biotite and significant hornblende		18_crystalline
Late Pleistocene igneous rocks	rhyolite	Q2rer	Rhyolite lava containing biotite and significant hornblende; variably with lesser pumice and breccia as a carapace		18_crystalline
Late Pleistocene igneous rocks	tephra	Q2rop	Rhyolite pumice tephra containing hornblende and biotite with minor clinopyroxene		18_crystalline
Late Pleistocene igneous rocks	rhyolite	Q2ror	Rhyolite lava containing hornblende and biotite with minor clinopyroxene; variably with lesser pumice and breccia as a carapace		18_crystalline
Late Pleistocene hill slope deposits	gravel	Q2s	Variable gravelly scree or colluvium deposits on >20 deg slopes; may merge with alluvial fans; may include minor glacial tills	Late Last Glacial slope deposit	14_moraineTill

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Pleistocene glacier deposits	till	Q2t	Generally unweathered bouldery till; poorly sorted mixtures of gravel/sand/silt/clay; well-preserved moraine ridges	Late Last Glacial till	14_moraineTill
Late Pleistocene glacier deposits	till	Q2t	Bouldery till in cirques; well-preserved moraine ridges or remobilised (rock glaciers); merges with scree/slope deposits	Late Last Glacial till	14_moraineTill
Late Pleistocene glacier deposits	till	Q2t	Generally unweathered bouldery till; poorly sorted mixtures of gravel/sand/silt/clay; possibly a kame terrace with reworked till	Late Last Glacial till	14_moraineTill
Late Pleistocene glacier deposits	till	Q2t	Generally unweathered, unsorted to sorted, loose sandy gravel silt and sand (till) in terminal and ground moraines	till	14_moraineTill
Late Pleistocene glacier deposits	gravel	Q2t	Poorly sorted till	glacial deposits	14_moraineTill
Late Pleistocene glacier deposits	till	Q2t	Generally unweathered, unsorted, loose, bouldery gravel sand and silt (till) in moraine remnants	till	14_moraineTill
Late Pleistocene glacier deposits	gravel	Q2t	Till		14_moraineTill
Late Pleistocene glacier deposits	till	Q2t	Bouldery till in well-preserved moraine ridges and flowed deposits, merging with scree	till	14_moraineTill
Late Pleistocene glacier deposits	till	Q2t	Generally unweathered, unsorted to sorted, loose sandy gravel, silt and sand (till) in terminal and ground moraines	Late Last Glacial till	14_moraineTill
Late Pleistocene glacier deposits	gravel	Q2t	Generally unweathered bouldery till; mixtures of gravel/sand/silt/clay; in well-defined valley or cirque moraines	Late Last Glacial till	14_moraineTill
Late Pleistocene glacier deposits	till	Q2t	Generally unweathered bouldery till; mixtures of gravel/sand/silt/clay; in well-defined valley moraines	Late Last Glacial till	14_moraineTill
Late Pleistocene glacier deposits	gravel	Q2t_ac	Generally unweathered bouldery till; mixtures of gravel/sand/silt/clay; in well-defined valley moraines	Late Last Glacial till	14_moraineTill
Late Pleistocene glacier deposits	gravel	Q2t_bf	Generally unweathered bouldery till; mixtures of gravel/sand/silt/clay; in well-defined valley moraines	Late Last Glacial till	14_moraineTill
Late Pleistocene glacier deposits	gravel	Q2t_em	Generally unweathered bouldery till; mixtures of gravel/sand/silt/clay; in well-defined valley moraines	Late Last Glacial till	14_moraineTill

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Pleistocene glacier deposits	gravel	Q2t_hk	Generally unweathered bouldery till; mixtures of gravel/sand/silt/clay; in well-defined valley moraines	Late Last Glacial till	14_moraineTill
Late Pleistocene glacier deposits	gravel	Q2t_js	Generally unweathered bouldery till; mixtures of gravel/sand/silt/clay; in well-defined valley moraines	Late Last Glacial till	14_moraineTill
Late Pleistocene glacier deposits	gravel	Q2t_la	Generally unweathered bouldery till; mixtures of gravel/sand/silt/clay; in well-defined valley moraines	Late Last Glacial till	14_moraineTill
Late Pleistocene glacier deposits	gravel	Q2t_lh	Generally unweathered bouldery till; mixtures of gravel/sand/silt/clay; in well-defined valley moraines	Late Last Glacial till	14_moraineTill
Late Pleistocene glacier deposits	gravel	Q2t_mj	Generally unweathered bouldery till; mixtures of gravel/sand/silt/clay; in well-defined valley moraines	Late Last Glacial till	14_moraineTill
Late Pleistocene glacier deposits	gravel	Q2t_mn	Generally unweathered bouldery till; mixtures of gravel/sand/silt/clay; in well-defined valley moraines	Late Last Glacial till	14_moraineTill
Late Pleistocene glacier deposits	gravel	Q2t_sl	Generally unweathered bouldery till; mixtures of gravel/sand/silt/clay; in well-defined valley moraines	Late Last Glacial till	14_moraineTill
Late Pleistocene glacier deposits	gravel	Q2t_tc	Generally unweathered bouldery till; mixtures of gravel/sand/silt/clay; in well-defined valley moraines	Late Last Glacial till	14_moraineTill
Late Pleistocene glacier deposits	gravel	Q2t_tk	Generally unweathered bouldery till; mixtures of gravel/sand/silt/clay; in well-defined valley moraines	Late Last Glacial till	14_moraineTill
Late Pleistocene glacier deposits	gravel	Q2t_tr	Generally unweathered bouldery till; mixtures of gravel/sand/silt/clay; in well-defined valley moraines	Late Last Glacial till	14_moraineTill
Late Pleistocene glacier deposits	gravel	Q2t_tt	Generally unweathered bouldery till; mixtures of gravel/sand/silt/clay; in well-defined valley moraines	Late Last Glacial till	14_moraineTill
Late Pleistocene igneous rocks	andesite	Q2tb	Andesite lava and welded scoria from Blue Lake crater; includes "Rotopaunga Scoria" of Nairn 1997		18_crystalline
Late Pleistocene glacier deposits	till	Q2tb	Generally unweathered, brownish-grey, bouldery till; mix of gravel/sand/silt/clay; in well-defined valley moraines	Early-mid LGM till	14_moraineTill
Late Pleistocene glacier deposits	till	Q2te	Sandy to bouldery gravel (till) in extensive ground, lateral, and terminal moraines	till	14_moraineTill
Late Pleistocene glacier deposits	till	Q2te	Sandy to bouldery gravel (till) in extensive ground, lateral, and terminal moraines	Late Last Glacial till	14_moraineTill
Late Pleistocene glacier deposits	till	Q2te	Loose, poorly sorted, bouldery gravel, sand, and silt (till); often with contorted bedding	till	14_moraineTill

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Pleistocene glacier deposits	till	Q2te	Loose, poorly sorted, bouldery gravel, sand, and silt (till); often with contorted bedding	Late Last Glacial till	14_moraineTill
Late Pleistocene glacier deposits	till	Q2th	Unsorted bouldery clay-rich gravel (till) with minor banded silt and sand lenses	till	14_moraineTill
Late Pleistocene igneous rocks	andesite	Q2th2	Andesite lava flows from North Crater		18_crystalline
Late Pleistocene igneous rocks	andesite	Q2th3	Andesite lava flows from North Crater		18_crystalline
Late Pleistocene igneous rocks	andesite	Q2th4	Youngest andesite lava flows and minor scoria from North Crater		18_crystalline
Late Pleistocene igneous rocks	scoria	Q2ths	Welded and non-welded scoriaceous andesite mantling upper slopes of North Crater		18_crystalline
Late Pleistocene igneous rocks	andesite	Q2tm2	Andesite lava flows from vents near lower Te Mari Crater		18_crystalline
Late Pleistocene glacier deposits	till	Q2tme	Unsorted bouldery clay-rich gravel (till) with minor banded silt and sand lenses	till	14_moraineTill
Late Pleistocene glacier deposits	till	Q2tp	Generally unweathered, grey, bouldery till; mix of gravel/sand/silt/clay; in well-defined valley moraines	Late LGM till	14_moraineTill
Late Pleistocene igneous rocks	andesite lava	Q2v	Hornblende andesite lava	Pukeiti lava	18_crystalline
Late Pleistocene igneous rocks	andesite	Q2vm	morphologically fresh, crystal-rich lava flows ranging from basalt to dacite, and tuff		18_crystalline
Late Pleistocene igneous rocks	tephra	Q2vmp	Rhyolite pumice tephra containing hornblende and biotite		18_crystalline
Late Pleistocene igneous rocks	rhyolite	Q2vmr	Rhyolite lava containing hornblende and biotite; variably with lesser pumice and breccia as a carapace		18_crystalline
Late Pleistocene igneous rocks	tephra	Q2wip	Rhyolite pumice tephra lacking biotite		18_crystalline
Late Pleistocene igneous rocks	rhyolite	Q2wir	Rhyolite lava lacking biotite; variably with lesser pumice and breccia as a carapace		18_crystalline
Late Pleistocene river deposits	gravel	Q3-4al	Gravel, sand and silt.	alluvial terrace deposits	16_terrace
Late Pleistocene river deposits	gravel	Q3af	Poorly sorted angular gravel, sand and mud.	alluvial fan	10_fan

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Pleistocene river deposits	gravel	Q3af	Poorly sorted steep fan gravel deposits	fan deposits	10_fan
Late Pleistocene river deposits	gravel	Q3af	Poorly sorted steep fan gravel deposits	Fan deposits	10_fan
Late Pleistocene river deposits	gravel	Q3af	Alluvial and colluvial fan deposits consisting of poorly sorted, weakly consolidated gravel, sand, clay and loess	Ratan alluvial and colluvial fan deposits	10_fan
Late Pleistocene river deposits	gravel	Q3af	Alluvial and colluvial fan deposits consisting of poorly sorted, weakly consolidated gravel, sand, clay and loess	Rata alluvial and colluvial fan*	10_fan
Late Pleistocene river deposits	sand	Q3ag	laminated to cross-bedded gravelly coarse sand; also gravel layers; silt beds at lower levels	alluvium	06_alluvium
Late Pleistocene river deposits	sand	Q3ag	laminated to cross-bedded gravelly sand; also gravel layers; silt beds at lower levels	alluvium	06_alluvium
Late Pleistocene river deposits	sand	Q3ah	Cross-bedded pumice sand, silt and gravel with interbedded peat		06_alluvium
Late Pleistocene river deposits	gravel	Q3al	Moderately weathered, poorly to moderately sorted gravel with minor sand and silt underlying terraces; includes minor fan deposi	Rata alluvial terrace deposits	16_terrace
Late Pleistocene river deposits	gravel	Q3al	Weathered; poorly sorted to moderately sorted gravel underlying loess-covered; commonly eroded aggradational surfaces	Alluvial deposits	06_alluvium
Late Pleistocene river deposits	gravel	Q3al	Weathered; poorly sorted to moderately sorted gravel underlying loess-covered; commonly eroded aggradational surfaces	alluvial deposits	06_alluvium
Late Pleistocene river deposits	gravel	Q3al	partly consolidated moderately weathered gravel and sand	terrace alluvium	16_terrace
Late Pleistocene river deposits	gravel	Q3al	weathered, poorly to moderately sorted gravel with loess, sand and silt	alluvium	06_alluvium
Late Pleistocene river deposits	gravel	Q3al	Moderately weathered, poorly to moderately sorted gravel with minor sand and silt underlying terraces; includes minor fan depos*	Rata alluvial terrace deposits	16_terrace
Late Pleistocene river deposits	gravel	Q3al	Gravel, sand and silt.	alluvial terrace deposits	16_terrace

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Pleistocene river deposits	gravel	Q3al_2al	Weathered; poorly sorted to moderately sorted gravel underlying loess-covered; commonly eroded aggradational surfaces	alluvial deposits	06_alluvium
Late Pleistocene shoreline deposits	gravel	Q3b	Well-rounded & bedded quartz-lithic gravel, sand and peat on marine bench remnants between 30 to 60m ASL; boulder layer at base	marine terrace gravel	16_terrace
Late Pleistocene shoreline deposits	sand	Q3b	sand and gravel	marine terrace	16_terrace
Late Pleistocene lahar deposits	debris	Q3ha	Laharic breccia of andesite cobbles and boulders in a muddy matrix		15_undifSed
Late Pleistocene lahar deposits	gravel	Q3ha	Conglomerate| sand and peat overlain by laharic andesite breccia	Ngaere Fm over Opunake Fm	15_undifSed
Late Pleistocene lahar deposits	gravel	Q3hh	Massive to well bedded andesitic gravel and sand, and minor debris deposits	Undifferentiated Late Quaternary lahars (Ruapehu)	15_undifSed
Late Pleistocene lahar deposits	gravel	Q3hk	Bedded sands| peat and andesite conglomerate	Opunake Fm over Q5 beach deposits	09_beachBarDune
Late Pleistocene lahar deposits	debris	Q3hk	Conglomerate overlying laharic breccia of andesite cobbles with peat	Opunake Fm over Stratford Fm	15_undifSed
Late Pleistocene lahar deposits	gravel	Q3hk	Multiple beds of consolidated andesitic conglomerate and sand		15_undifSed
Late Pleistocene lake deposits	silt	Q3lk	Lacustrine pumice-bearing sandy or clayey silt	Rotorua basin lake sediments	08_lacustrine
Late Pleistocene igneous rocks	ignimbrite	Q3m	Rhyolite ignimbrite and fall deposits; includes coarse-grained pumice ash, lapilli and block beds	Ignimbrite members	18_crystalline
Middle Pleistocene igneous rocks	rhyolite	Q3m/Q12o	Rhyolite lava variably with lesser pumice and breccia as a carapace; overlain by rhyolite fall deposits.		18_crystalline
Late Pleistocene igneous rocks	ignimbrite	Q3m/Q4ro	Non-welded rhyolite ignimbrite; minor fall deposits.overlain by rhyolite fall deposits.		18_crystalline
Middle Pleistocene igneous rocks	tephra	Q3m/Q7vp	Rhyolite tepra including pumice ash and lapilli and non-welded to highly welded ignimbrite; overlain by rhyolite fall deposits.		18_crystalline
Middle Pleistocene igneous rocks	ignimbrite	Q3m/Q8ma	Pink- to purplish-grey, unwelded to welded columnar jointed, locally rhyolite ignimbrite; overlain by rhyolite fall deposits.		18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Middle Pleistocene igneous rocks	ignimbrite	Q3m/Q9w	Complex sequence of partly welded, crystal-rich ignimbrites; overlain by rhyolite fall deposits.		18_crystalline
Late Pleistocene - Holocene river deposits	gravel	Q3m/lQal	Moderately weathered, poorly to moderately sorted gravel with minor sand and silt; overlain by rhyolite fall deposits.	alluvial terrace deposits and airfall members	16_terrace
Middle Pleistocene - Late Pleistocene lake deposits	silt	Q3m/lQlk	Lacustrine pumice-bearing sandy or clayey silt; overlain by rhyolite fall deposits.	lacustrine sediments	08_lacustrine
Late Pleistocene igneous rocks	dacite	Q3m/lQpd	Dacite lava and pumice breccia; overlain by rhyolite fall deposits.		18_crystalline
Middle Pleistocene lake deposits	silt	Q3m/mQlk	Silty, commonly diatomaceous, millimetre-laminated lacustrine sediments; overlain by rhyolite fall deposits.	(undifferentiated)	08_lacustrine
Late Pleistocene igneous rocks	ignimbrite	Q3o	Non-welded ignimbrite and phreatomagmatic fall deposits, and reworked ignimbrite	Oruanui Formation	18_crystalline
Late Pleistocene igneous rocks	ignimbrite	Q3o	Non-welded ignimbrite and phreatomagmatic fall deposits, and reworked ignimbrite.		18_crystalline
Late Pleistocene igneous rocks	tephra	Q3op	Rhyolite pumice tephra		18_crystalline
Late Pleistocene igneous rocks	ignimbrite	Q3or	Non-welded ignimbrite and phreatomagmatic fall deposits, and reworked ignimbrite.		18_crystalline
Late Pleistocene igneous rocks	andesite	Q3th1	Heavily faulted andesite lava flows from North Crater		18_crystalline
Late Pleistocene igneous rocks	andesite	Q3tm1	Oldest andesite lava flows erupted from vents near Te Mari craters		18_crystalline
Late Pleistocene igneous rocks	tephra	Q3trp	Rhyolite pumice tephra containing hornblende with minor clinopyroxene		18_crystalline
Late Pleistocene igneous rocks	rhyolite	Q3trr	Rhyolite lava containing hornblende with minor clinopyroxene; variably with lesser pumice and breccia as a carapace		18_crystalline
Late Pleistocene igneous rocks	andesite	Q3tu	Poorly exposed andesite lavas and thin, widely dispersed welded scorias		18_crystalline
Late Pleistocene igneous rocks	basalt	Q3vb	Basalt scoria beds		18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Pleistocene igneous rocks	andesite lava	Q3vm	Medium grey, phenocryst-rich andesite lava and breccia		18_crystalline
Late Pleistocene igneous rocks	andesite	Q3vm	crystal-rich lava flows ranging from basalt to dacite, and tuff		18_crystalline
Late Pleistocene igneous rocks	rhyolite	Q3vmr	plagioclase-orthopyroxene± quartz± hornblende± biotite rhyolite lava domes and carapace breccia		18_crystalline
Late Pleistocene igneous rocks	andesite lava	Q3vo	Reddish-brown, andesitic scoria and lava with common olivine phenocrysts		18_crystalline
Late Pleistocene igneous rocks	rhyolite	Q3vr	Rhyolite lava		18_crystalline
Late Pleistocene igneous rocks	rhyolite	Q3vtr	Rhyolite lava, crystal rich containing hornblende and biotite		18_crystalline
Late Pleistocene river deposits	gravel	Q4-5al	Gravel, sand and silt.	alluvial terrace deposits	16_terrace
Middle Pleistocene - Late Pleistocene river deposits	gravel	Q4-6a	Slightly weathered; variable mixtures of gravel/sand/silt/clay forming isolated slightly elevated terraces	Medium-age alluvium/outwash	12_outwash
Middle Pleistocene - Late Pleistocene river deposits	gravel	Q4-6a	Grey-brown, slightly to moderately weathered mixtures of gravel/sand/silt/clay forming isolated slightly elevated river terrace	Medium-age alluvium	06_alluvium
Middle Pleistocene - Late Pleistocene river deposits	gravel	Q4-6a	Grey-brown, slightly to moderately weathered mixtures of gravel/sand/silt/clay forming isolated slightly elevated river	Medium-age alluvium	06_alluvium
Middle Pleistocene - Late Pleistocene river deposits	gravel	Q4-6f	Slightly weathered; variable mixtures of gravel/sand/silt in dissected alluvial fan complexes	Medium-age alluvial fan	10_fan
Middle Pleistocene - Late Pleistocene glacier deposits	till	Q4-6t	Unweathered to slightly weathered, sandy bouldery gravel (till) in lateral moraine benches and terminal loops	Early Last Glacial till	14_moraineTill
Middle Pleistocene - Late Pleistocene glacier deposits	gravel	Q4-6t	Slightly weathered; variable mixtures of gravel/sand/silt/clay forming scattered outcrops or subdued moraine remnants	Medium-age till	14_moraineTill
Middle Pleistocene - Late Pleistocene river deposits	gravel	Q4-8a	Slightly to moderately weathered mixtures of gravel/sand/silt/clay forming isolated outcrops in Forest Creek	Medium-old river alluvium	06_alluvium

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Middle Pleistocene - Late Pleistocene river deposits	gravel	Q4-8f	Slightly to highly weathered mixtures of gravel/sand/silt forming dissected fans at Snow River	Medium-old alluvial fan	10_fan
Middle Pleistocene - Late Pleistocene lake deposits	silt	Q46lk	Silty, mostly diatomaceous, millimetre-laminated lacustrine sediments; dominated by pumice, lithics and crystals.	Rotorua basin lake sediments	08_lacustrine
Middle Pleistocene - Late Pleistocene igneous rocks	tephra	Q46vmp	ignimbrite, block and/or ash flow deposits and minor airfall pumice		18_crystalline
Late Pleistocene river deposits	gravel	Q4a	Grey-brown, slightly weathered mixtures of gravel/sand/silt/clay alluvium forming isolated slightly elevated river terrace	Older alluvium	06_alluvium
Late Pleistocene river deposits	gravel	Q4a	Gravel, sand and silt of low river terraces with patchy loess cover in places	alluvium	06_alluvium
Late Pleistocene river deposits	gravel	Q4a	Slightly weathered; variable mixtures of gravel/sand/silt/clay forming slightly dissected terrace remnants	Early Last Glacial alluvium	06_alluvium
Late Pleistocene river deposits	gravel	Q4a_b2	Slightly weathered; variable mixtures of gravel/sand/silt/clay forming slightly dissected terrace remnants	Early Last Glacial outwash	12_outwash
Late Pleistocene river deposits	gravel	Q4a_lo	Slightly weathered; variable mixtures of gravel/sand/silt/clay forming slightly dissected terrace remnants or plains	Early Last Glacial outwash	12_outwash
Late Pleistocene river deposits	gravel	Q4af	Slightly weathered gravel and sand in sloping and higher alluvial fan remnants; commonly dissected	Early Last Glacial alluvial fan	10_fan
Late Pleistocene river deposits	gravel	Q4af	Poorly sorted steep fan gravel deposits	fan deposits	10_fan
Late Pleistocene river deposits	gravel	Q4af	locally derived gravels in degraded fans	alluvial fans	10_fan
Late Pleistocene river deposits	gravel	Q4af	locally derived sandy gravel in alluvial fans overlying Q6 outwash surfaces	alluvial fan	10_fan
Late Pleistocene river deposits	gravel	Q4af	sandy to clayey locally derived gravel in fans grading onto terraces	alluvial fans	10_fan
Late Pleistocene river deposits	gravel	Q4af	slightly weathered gravel sand silt and loess	alluvial fan	10_fan

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Pleistocene river deposits	gravel	Q4af	locally derived angular to rounded sandy gravel	alluvial fan	10_fan
Late Pleistocene river deposits	gravel	Q4af	sandy gravel in small alluvial fans	alluvial fan	10_fan
Late Pleistocene river deposits	gravel	Q4af	Weathered alluvial and colluvial fan deposits consisting of poorly sorted, weakly consolidated gravel, sand, clay and loess	Porewa alluvial and colluvial f*	06_alluvium
Late Pleistocene river deposits	gravel	Q4al	Weathered, poorly to moderately sorted gravel and loess with minor sand and silt underlying terraces; includes minor fan deposi*	Porewa alluvial terrace deposits	16_terrace
Late Pleistocene river deposits	gravel	Q4al	Slightly weathered, loose, gravel and sand in intermediate terraces	Early Last Glacial alluvium	06_alluvium
Late Pleistocene river deposits	gravel	Q4al	schist-greywacke-quartz sandy gravel in Clutha catchment: sandy gravel in outwash and alluvial terraces	terrace gravels	16_terrace
Late Pleistocene river deposits	gravel	Q4al	Unweathered to slightly weathered silty to sandy gravel	terrace alluvium	16_terrace
Late Pleistocene river deposits	gravel	Q4al	sandy gravel in outwash and alluvial terraces	alluvial terraces	16_terrace
Late Pleistocene river deposits	gravel	Q4al	Weathered; poorly sorted to moderately sorted gravel underlying loess-covered; commonly eroded aggradational surfaces	Alluvial deposits	06_alluvium
Late Pleistocene river deposits	gravel	Q4al	sandy gravel in intermediate terraces	alluvial terraces	16_terrace
Late Pleistocene river deposits	gravel	Q4al	Moderately weathered, poorly to moderately sorted gravel with minor sand and silt underlying eroded terraces; includes minor fan	Porewa alluvial terrace deposits	16_terrace
Late Pleistocene river deposits	gravel	Q4al	Weathered; poorly sorted to moderately sorted gravel underlying loess-covered; commonly eroded aggradational surfaces	alluvial deposits	06_alluvium
Late Pleistocene river deposits	gravel	Q4al	sandy greywacke gravel overlain by loess; schist-greywacke-quartz sandy gravel in the Clutha catchment	alluvial terraces	16_terrace
Late Pleistocene river deposits	gravel	Q4al	River gravel and sand		06_alluvium

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Middle Pleistocene - Late Pleistocene river deposits	gravel	Q4al	schist-greywacke-quartz sandy gravel in Clutha catchment: sandy gravel in outwash and alluvial terraces	terrace gravels	16_terrace
Late Pleistocene river deposits	gravel	Q4al	weathered, poorly to moderately sorted gravel with loess, sand and silt	alluvium	06_alluvium
Middle Pleistocene - Late Pleistocene river deposits	gravel	Q4al	sandy gravel in outwash and alluvial terraces	alluvial terraces	16_terrace
Late Pleistocene river deposits	gravel	Q4al	Gravel, sand and silt.	alluvial terrace deposits	16_terrace
Late Pleistocene river deposits	gravel	Q4al_2af	Weathered; poorly sorted to moderately sorted gravel underlying loess-covered; commonly eroded aggradational surfaces	alluvial deposits	06_alluvium
Late Pleistocene river deposits	gravel	Q4al_2al	Weathered; poorly sorted to moderately sorted gravel underlying loess-covered; commonly eroded aggradational surfaces	alluvial deposits	06_alluvium
Late Pleistocene river deposits	gravel	Q4ao	slightly weathered sandy gravel	outwash	12_outwash
Late Pleistocene river deposits	gravel	Q4ao	Degradation surface associated with White Burn advance cut into slightly weathered sandy gravel of Q6 South Von Fmn outwash	outwash	12_outwash
Late Pleistocene river deposits	gravel	Q4ao	Unweathered to slightly weathered, loose, sandy to silty, well rounded gravel usually on large outwash plains	outwash	12_outwash
Late Pleistocene river deposits	gravel	Q4ao	slightly weathered sandy gravel outwash in terraces, includes degradation terraces	outwash	12_outwash
Late Pleistocene river deposits	gravel	Q4ao	loose sandy to silty well rounded gravel usually on large outwash plains	outwash	12_outwash
Late Pleistocene river deposits	gravel	Q4ao	Grey-brown, slightly weathered mixtures of gravel/sand/silt/clay fluvioglacial outwash alluvium adjacent to & derived from till	Early Last Glacial outwash	12_outwash
Late Pleistocene river deposits	gravel	Q4ao	Slightly weathered, loose, sandy, cobbly, to bouldery outwash gravel	Early Last Glacial outwash	12_outwash
Late Pleistocene river deposits	gravel	Q4ao	sandy to bouldery outwash gravels	outwash gravel	12_outwash

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Pleistocene river deposits	gravel	Q4ao	sandy gravel in outwash plains associated with extensive moraines	outwash	12_outwash
Late Pleistocene shoreline deposits	gravel	Q4b	Beach deposits consisting of marine gravel with sand; commonly underlying loess and fan deposits	beach deposits	09_beachBarDune
Late Pleistocene windblown deposits	loess	Q4e	silty loess forming dune fields on Q4 terraces	loess	11_loess
Late Pleistocene igneous rocks	ignimbrite	Q4eq	Non-welded biotite-hornblende rhyolite ignimbrite commonly with high crystal content; minor fall deposits		18_crystalline
Late Pleistocene river deposits	gravel	Q4f	Slightly weathered; variable mixtures of gravel/sand/silt in dissected alluvial fan complexes	Early Last Glacial alluvial fan	10_fan
Late Pleistocene river deposits	gravel	Q4f	Boulders, gravel, sand and clay forming sloping low alluvial fans	fan	10_fan
Late Pleistocene lahar deposits	gravel	Q4h	Multiple beds of poorly consolidated andesitic conglomerate and sand		15_undifSed
Late Pleistocene lahar deposits	debris	Q4hs	Laharic breccia of andesite cobbles overlying bedded sands and conglomerate	Stratford Fm over Q7 beach deposits	09_beachBarDune
Late Pleistocene lahar deposits	debris	Q4hs	Laharic breccia of andesite cobbles in a muddy matrix, and conglomerate and sand with interbedded peat		15_undifSed
Late Pleistocene lahar deposits	debris	Q4hs	Laharic breccia of andesite cobbles overlying bedded sands| peat and conglomerate	Stratford Fm over Q5 beach deposits	09_beachBarDune
Late Pleistocene lake deposits	silt	Q4k	lake deposits consisting of massive to laminated silt and sand	lake sediments	08_lacustrine
Late Pleistocene river deposits	gravel	Q4o	gravel; sand; silt and clay forming outwash plains and traceable upstream to moraine	outwash	12_outwash
Late Pleistocene igneous rocks	ignimbrite	Q4ro	Non-welded rhyolite ignimbrite usually with moderate to high crystal content; includes minor fall deposits		18_crystalline
Late Pleistocene glacier deposits	till	Q4t	Unweathered to slightly weathered, sandy bouldery gravel (till) in lateral moraine benches and terminal loops	till	14_moraineTill
Late Pleistocene glacier deposits	till	Q4t	Grey-brown, slightly weathered bouldery till; variable mixtures of gravel/sand/silt/clay, in subdued valley moraine remnants	Early Last Glacial till	14_moraineTill

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Pleistocene glacier deposits	gravel	Q4t	Till; slightly weathered in some localities	glacial deposits	14_moraineTill
Late Pleistocene glacier deposits	till	Q4t	bouldery sandy till in moraine remnants	moraine	14_moraineTill
Late Pleistocene glacier deposits	gravel	Q4t	Slightly weathered bouldery till; mixtures of gravel/sand/silt/clay; in subdued valley moraine remnants	Early Last Glacial till	14_moraineTill
Late Pleistocene glacier deposits	till	Q4t	Slightly weathered, loose, sandy bouldery gravel (till) in lateral moraine benches and terminal loops	Early Last Glacial till	14_moraineTill
Late Pleistocene glacier deposits	till	Q4t	Grey-brown, slightly weathered bouldery till; variably mixtures of gravel/sand/silt/clay, in moraine ridges of lower Cascade	Early Last Glacial till	14_moraineTill
Late Pleistocene glacier deposits	gravel	Q4t	Till		14_moraineTill
Late Pleistocene glacier deposits	till	Q4t	Unweathered to slightly weathered, loose, poorly sorted, bouldery gravel, sand, and silt (till); often with contorted bedding	till	14_moraineTill
Late Pleistocene glacier deposits	till	Q4t	Bouldery till in moraine ridges	till	14_moraineTill
Late Pleistocene glacier deposits	gravel	Q4t_b2	Slightly weathered bouldery till; mixtures of gravel/sand/silt/clay; in subdued valley moraine remnants	Early Last Glacial till	14_moraineTill
Late Pleistocene river deposits	gravel	Q4t_lo	Slightly weathered bouldery till; mixtures of gravel/sand/silt/clay; in subdued valley moraine remnants	Early Last Glacial till	14_moraineTill
Middle Pleistocene - Late Pleistocene igneous rocks	tephra	Q57vp	Rhyolite tepra; includes pumice ash and lapilli; non-welded to highly welded ignimbrite; includes intercalated paleosols	includes Onuku pyroclastics	18_crystalline
Late Pleistocene river deposits	gravel	Q5a	Slightly weathered and cemented gravel of alluvial terraces at Waikouaiti and Shag river estuaries	alluvium	06_alluvium
Late Pleistocene river deposits	gravel	Q5af	Poorly sorted angular gravel, sand and mud.	alluvial fan	10_fan
Late Pleistocene river deposits	gravel	Q5al	River gravel and sand		06_alluvium

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Pleistocene river deposits	gravel	Q5al	Weathered; poorly sorted to moderately sorted gravel underlying loess-covered; commonly eroded aggradational surfaces	Alluvial deposits	06_alluvium
Late Pleistocene river deposits	gravel	Q5al	Gravel, sand and silt.	alluvial terrace deposits	16_terrace
Late Pleistocene river deposits	gravel	Q5al	slightly weathered gravel sand silt and loess	terrace alluvium	16_terrace
Late Pleistocene river, lake and swamp deposits	gravel	Q5as	Weathered alluvial gravel; blue-grey silty clay; and peat of alluvial; swamp and possibly lacustrine origin		10_fan
Late Pleistocene shoreline deposits	gravel	Q5b	Weathered, well-rounded gravel, sand and peat on marine bench remnants between 60 to 90m ASL	marine terrace gravel	16_terrace
Late Pleistocene shoreline deposits	sand	Q5b	dunes at 10m ASL at Waipapa Point	dunes	09_beachBarDune
Late Pleistocene shoreline deposits	sand	Q5b	slightly weathered gravel sand silt and loess	marine terrace deposits	16_terrace
Late Pleistocene shoreline deposits	gravel	Q5b	Slightly weathered beach deposits consisting of marine sand on raised terraces	alluvial deposits	15_undifSed
Late Pleistocene shoreline deposits	sand	Q5b	Slightly weathered sand and gravel beneath coastal terraces up to 120 m above sea level	Raised marine terrace	16_terrace
Late Pleistocene shoreline deposits	gravel	Q5b	Beach deposits consisting of marine gravel with sand; commonly underlying loess and fan deposits	beach deposits	09_beachBarDune
Late Pleistocene shoreline deposits	sand	Q5b	sand and gravel	marine terrace deposits	16_terrace
Late Pleistocene shoreline deposits	gravel	Q5b	Pebbly to bouldery gravel, sand, and minor peat underlying marine benches behind old sea cliffs gravel quartz-dominated east of	marine terraces	16_terrace
Late Pleistocene shoreline deposits	gravel	Q5b	Beach deposits consisting of marine gravel with sand; commonly underlying loess and fan deposits	Beach deposits	09_beachBarDune
Late Pleistocene shoreline deposits	gravel	Q5b	beach deposits of marine gravel and sand, with overlying loess deposits	beach deposits	09_beachBarDune
Late Pleistocene shoreline deposits	sand	Q5b	Rapanui, Hauriri & Inaha terrace coverbeds comprising shallow marine conglomerate, shellbeds, dune sands and peat	Rapanui, Hauriri & Inaha marine terrace deposits	16_terrace

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Pleistocene shoreline deposits	sand	Q5b	Beach and shallow marine sand, gravel and mud	Last Interglacial marine deposi*	15_undifSed
Late Pleistocene shoreline deposits	sand	Q5b	Slightly weathered sand with pebbles and shells, overlain by loess, on raised marine terraces from Oamaru to Waikouaiti	raised beaches	09_beachBarDune
Late Pleistocene shoreline deposits	sand	Q5b	Rapanui (NT2) terrace coverbreds comprising a range of shallow marine to paralic sediments.	NT2 (Rapanui) terrace deposits	16_terrace
Late Pleistocene shoreline deposits	sand	Q5b	Marine sand and gravel		15_undifSed
Late Pleistocene lahar deposits	debris	Q5hw	Laharic breccia of andesite cobbles overlying bedded sands| peat and conglomerate	Okawa Fm over Q5 beach deposits	09_beachBarDune
Middle Pleistocene lahar deposits	debris	Q5hw	Laharic breccia of andesite cobbles overlying bedded sands and conglomerate	Okawa Fm over Q7 beach deposits	09_beachBarDune
Late Pleistocene lahar deposits	debris	Q5hw	Laharic breccia of andesite cobbles and boulders in a muddy matrix		15_undifSed
Late Pleistocene lahar deposits	debris	Q5hw	Laharic breccia overlying bedded sands| peat and conglomerate and laharic breccia	Okawa Fm over Q5 bch and Motonui Fm	15_undifSed
Late Pleistocene hill slope deposits	breccia	Q5l	Chaotic unsorted debris in landslide; mixture of lithological units	Relict landslide deposit	15_undifSed
Late Pleistocene igneous rocks	rhyolite	Q5te	rhyolite lava	Echo Cliffs rhyolite	18_crystalline
Late Pleistocene igneous rocks	andesite	Q5ts	Extensive andesite lava flows, vent breccias, tephra, minor lake sediments and mantling scoria deposits		18_crystalline
Late Pleistocene igneous rocks	andesite	Q5tw	Extensive andesite to dacite lava flows, vent breccias, intrusive bodies, scoria, tephra and debris flow deposits		18_crystalline
Late Pleistocene igneous rocks	andesite lava	Q5vg	Hornblende andesite lava	German Hill lava	18_crystalline
Late Pleistocene igneous rocks	rhyolite	Q5vmr	plagioclase-orthopyroxene± quartz± hornblende± biotite rhyolite lava domes and carapace breccia		18_crystalline
Late Pleistocene igneous rocks	rhyolite	Q5vmr	plagioclase-orthopyroxene± quartz rhyolite lava domes and carapace breccia	includes main Maroa complex	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Pleistocene igneous rocks	rhyolite	Q5vtr	Rhyolite lava		18_crystalline
Middle Pleistocene river deposits	gravel	Q6-8f	Moderately to highly weathered mixtures of gravel/sand/silt forming dissected high-level fans in Opihi catchment	Medium-old alluvial fan	10_fan
Middle Pleistocene river deposits	gravel	Q6a	Grey-brown, slightly to moderately weathered mixtures of gravel/sand/silt/clay alluvium forming scattered river terrace remnants	Medium age river alluvium	06_alluvium
Middle Pleistocene river deposits	gravel	Q6a	slightly weathered gravel and sand in alluvial terraces with some loess cover	alluvium	06_alluvium
Middle Pleistocene river deposits	gravel	Q6a	Slightly weathered gravel and minor fan deposits forming intermediate aggradation terraces	alluvial deposits	06_alluvium
Middle Pleistocene river deposits	gravel	Q6a	Slightly to moderately weathered mixtures of gravel/sand/silt/clay forming scattered terrace remnants	Medium-age river alluvium	06_alluvium
Middle Pleistocene river deposits	gravel	Q6a_b1	Slightly to moderately weathered mixtures of gravel/sand/silt/clay forming scattered terrace remnants	Medium-age glacial outwash	12_outwash
Middle Pleistocene river deposits	gravel	Q6af	deeply weathered clay-rich sandy gravel in high fans off the Blue Mtns	alluvial fans	10_fan
Middle Pleistocene river deposits	gravel	Q6af	Slightly to moderately weathered, locally derived, sandy gravel in alluvial fans overlying Q6 outwash surfaces	alluvial fan	10_fan
Middle Pleistocene river deposits	gravel	Q6af	slightly weathered sand gravel and silt loess	alluvial fan	10_fan
Middle Pleistocene river deposits	gravel	Q6af	River gravel and sand		06_alluvium
Middle Pleistocene river deposits	gravel	Q6af	weathered gravel in high fans grading into Q6 terraces	alluvial fans	10_fan
Middle Pleistocene river deposits	gravel	Q6af	Very weathered alluvial and colluvial fan deposits consisting of poorly sorted, weakly consolidated gravel, sand, clay and loess	Marton alluvial and colluvial f*	06_alluvium
Middle Pleistocene river deposits	gravel	Q6af	Poorly sorted steep fan gravel deposits	fan deposits	10_fan

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Middle Pleistocene river deposits	gravel	Q6af	Poorly sorted steep fan gravel deposits	Fan deposits	10_fan
Middle Pleistocene river deposits	gravel	Q6al	weathered greywacke gravel overlain by loess greywacke-schist gravel remnants in Clutha catchment	terrace gravels	16_terrace
Middle Pleistocene river deposits	gravel	Q6al	River gravel and sand	alluvial deposits	06_alluvium
Middle Pleistocene river deposits	gravel	Q6al	weathered greywacke gravel overlain by loess greywacke-schist gravel remnants in Clutha catchment	terrace gravels	16_terrace
Middle Pleistocene river deposits	gravel	Q6al	moderately weathered clay-rich sandy gravel in high terraces	alluvial terraces	16_terrace
Middle Pleistocene river deposits	gravel	Q6al	Very weathered, poorly to moderately sorted gravel and loess with minor sand and silt underlying terraces; includes minor fan d*	Marton alluvial terrace deposits	16_terrace
Middle Pleistocene river deposits	gravel	Q6al	Weathered; poorly sorted to moderately sorted gravel underlying loess-covered; commonly eroded aggradational surfaces	Alluvial deposits	06_alluvium
Middle Pleistocene river deposits	gravel	Q6al	weathered greywacke gravel overlain by loess; greywacke-schist gravel remnants in Clutha catchment	terrace gravels	16_terrace
Middle Pleistocene river deposits	gravel	Q6al	River gravel and sand		06_alluvium
Middle Pleistocene river deposits	gravel	Q6al	Weathered, poorly to moderately sorted gravel with minor sand and silt underlying eroded terraces; includes minor fan deposits a	Marton alluvial terrace deposits	16_terrace
Middle Pleistocene river deposits	gravel	Q6al	highly weathered, poorly to moderately sorted gravel with loess, sand and silt	alluvium	06_alluvium
Middle Pleistocene river deposits	gravel	Q6al	Slightly to moderately weathered sandy gravel	terrace alluvium	16_terrace
Middle Pleistocene river deposits	gravel	Q6al	schist-greywacke-quartz sandy gravel in Clutha catchment: sandy gravel in outwash and alluvial terraces	terrace gravels	16_terrace

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Middle Pleistocene - Late Pleistocene river deposits	gravel	Q6al_4al	River gravel and sand	alluvial deposits	06_alluvium
Middle Pleistocene river deposits	gravel	Q6ao	Slightly to moderately weathered sandy gravel and gravelly sand	outwash	12_outwash
Middle Pleistocene river deposits	gravel	Q6ao	Slightly to moderately weathered sandy gravel	outwash	12_outwash
Middle Pleistocene river deposits	gravel	Q6ao	slightly weathered sandy outwash gravel	outwash gravel	12_outwash
Middle Pleistocene river deposits	gravel	Q6ao	Slightly to moderately weathered, bedded, gravelly to bouldery sand, and sandy outwash gravel in high level terraces	Medium-age outwash	12_outwash
Middle Pleistocene river deposits	gravel	Q6ao	Grey-brown, slightly to moderately weathered mixtures of gravel/sand/silt/clay outwash forming scattered river terrace remnants	Woodlands outwash	12_outwash
Middle Pleistocene shoreline deposits	sand	Q6b	sand and gravel	marine terrace deposits	16_terrace
Middle Pleistocene windblown deposits	loess	Q6e	at least 2 loess layers in upward-building loess-scape away from fluvial influence	loess	11_loess
Middle Pleistocene river deposits	gravel	Q6f	slightly weathered gravel and sand in sloping alluvial fans	fan	10_fan
Middle Pleistocene river deposits	gravel	Q6f	Slightly to moderately weathered mixtures of gravel/sand/silt/clay forming dissected alluvial fans	Medium-age alluvial fan	10_fan
Middle Pleistocene lahar deposits	debris	Q6h	Laharic breccia of andesite cobbles overlying bedded sands and conglomerate	Motonui Fm over Q7 beach deposits	09_beachBarDune
Middle Pleistocene lahar deposits	debris	Q6h	Laharic breccia of andesite cobbles and boulders in a muddy matrix		15_undifSed
Middle Pleistocene river deposits	gravel	Q6o	slightly weathered gravel and sand forming outwash plains traceable upstream to moraine	outwash	12_outwash
Middle Pleistocene glacier deposits	till	Q6t	Slightly to moderately weathered, sandy to clayey gravel (till) in extensive but subdued moraine topography	till	14_moraineTill
Middle Pleistocene glacier deposits	till	Q6t	Slightly to moderately weathered, loose, bouldery gravel, sand, and silt (till)	till	14_moraineTill

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Middle Pleistocene glacier deposits	gravel	Q6t	Slightly to moderately weathered mixtures of gravel/sand/silt/clay forming scattered moraine remnants	Medium-age till	14_moraineTill
Middle Pleistocene glacier deposits	gravel	Q6t	Till; slightly weathered in some localities		14_moraineTill
Middle Pleistocene glacier deposits	till	Q6t	Slightly to moderately weathered, sandy to gravelly till in isolated moraine remnants	Medium-age till	14_moraineTill
Middle Pleistocene glacier deposits	till	Q6t	Slightly to moderately bouldery and cemented till forming subdued morained ridges of lower Cascade valley	Medium-age till	14_moraineTill
Middle Pleistocene glacier deposits	gravel	Q6t	Till; slightly weathered in some localities	glacial deposits	14_moraineTill
Middle Pleistocene glacier deposits	gravel	Q6t	Slightly weathered; variable mixtures of gravel/sand/silt/clay forming scattered outcrops or subdued moraine remnants	Medium-age till	14_moraineTill
Middle Pleistocene glacier deposits	till	Q6t	slightly weathered bouldery till without geomorphic expression	till	14_moraineTill
Middle Pleistocene glacier deposits	gravel	Q6t_b1	Slightly to moderately weathered mixtures of gravel/sand/silt/clay forming scattered moraine remnants	Medium-age glacial till	14_moraineTill
Middle Pleistocene igneous rocks	rhyolite	Q6vmr	plagioclase-orthopyroxene± quartz± hornblende± biotite rhyolite lava domes and carapace breccia		18_crystalline
Middle Pleistocene igneous rocks	rhyolite	Q6vmr	plagioclase-orthopyroxene± quartz± hornblende rhyolite lava domes and carapace breccia		18_crystalline
Middle Pleistocene igneous rocks	rhyolite	Q6vur	Rhyolite lava		18_crystalline
Middle Pleistocene river deposits	gravel	Q7al	moderately weathered gravel and sand several metres of loess	terrace alluvium	16_terrace
Middle Pleistocene river deposits	gravel	Q7al	River gravel and sand often with weathered clasts		06_alluvium
Middle Pleistocene igneous rocks	ignimbrite	Q7at	non-welded to sintered plagioclase orthopyroxene rhyolitic ignimbrite with minor eutaxitic proximal facies; minor airfall tephra		18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Middle Pleistocene shoreline deposits	gravel	Q7b	Slightly to moderately weathered, dm-bedded gravel and gravelly sand on marine bench remnants between 90 to 150m ASL	marine terrace gravel	16_terrace
Middle Pleistocene shoreline deposits	gravel	Q7b	Slightly to moderately weathered, dm-bedded gravel and gravelly sand on marine bench remnants between 170 to 200m ASL	marine terrace gravel	16_terrace
Middle Pleistocene shoreline deposits	gravel	Q7b	Marine sand and gravel	beach deposits	09_beachBarDune
Middle Pleistocene shoreline deposits	gravel	Q7b	Pebbly gravel and sand with rare peat underlying high marine benches	marine terrace	16_terrace
Middle Pleistocene shoreline deposits	gravel	Q7b	Moderately weathered beach deposits consisting of marine sand on raised terraces	beach deposits	09_beachBarDune
Middle Pleistocene shoreline deposits	sand	Q7b	sand and gravel	marine terrace deposits	16_terrace
Middle Pleistocene shoreline deposits	sand	Q7b	moderately weathered sand gravel and silt	marine terrace deposits	16_terrace
Middle Pleistocene shoreline deposits	sand	Q7b	Marine sand and gravel		15_undifSed
Middle Pleistocene shoreline deposits	gravel	Q7b	Beach deposits consisting of marine gravel with sand; commonly underlying loess and fan deposits	Beach deposits	09_beachBarDune
Middle Pleistocene shoreline deposits	gravel	Q7b	Ngarino terrace coverbeds comprising shallow marine conglomerate, shellbeds, dune sands and peat	Ngarino marine terrace deposits	16_terrace
Middle Pleistocene lake deposits	silt	Q7k	Lake silts in the Murchison area		08_lacustrine
Middle Pleistocene lake deposits	silt	Q7k	Lake silts in the Murchison area	lake deposits	08_lacustrine
Middle Pleistocene igneous rocks	ignimbrite	Q7kiu	Rhyolite ignimbrite; crystal- and pumice-poor, pink and yellow through to vapour-phase-altered at top; minor fall deposits	Q7ki	18_crystalline
Middle Pleistocene igneous rocks	ignimbrite	Q7kiu	Rhyolite ignimbrite; crystal- and pumice-poor, pink and yellow through to vapour-phase-altered at top; minor fall deposits		18_crystalline
Middle Pleistocene igneous rocks	ignimbrite	Q7mk	Welded, in places collumnar jointed, rhyolite ignimbrite; pink to purple-grey vapour phase altered; minor fall deposits		18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Middle Pleistocene igneous rocks	ignimbrite	Q7mo	non-welded to vapour phase altered ignimbrite, low crystal content; mafic blebs		18_crystalline
Middle Pleistocene igneous rocks	ignimbrite	Q7oh	massive to cross-bedded, cream to light grey, non-welded rhyolite ignimbrite; minor fall deposits		18_crystalline
Middle Pleistocene igneous rocks	ignimbrite	Q7p	Rhyolite ignimbrite with brown matrix, orange pumice clasts, non-welded, cream-coloured base to welded jointed; minor fall depo*		18_crystalline
Middle Pleistocene igneous rocks	ignimbrite	Q7pke	ignimbrite, block and ash flow deposits, and minor airfall pumice	Western member	18_crystalline
Middle Pleistocene igneous rocks	ignimbrite	Q7pkw	hornblende-bearing ignimbrite, block and ash flow deposits, and minor airfall pumice	Eastern member	18_crystalline
Middle Pleistocene igneous rocks	dacite	Q7td	Crystal rich dacite lava containing clinopyroxene and abundant hornblende phenocrysts		18_crystalline
Middle Pleistocene igneous rocks	andesite	Q7vb	Low-silica andesite scoria and lava		18_crystalline
Middle Pleistocene igneous rocks	tephra	Q7vmp	ignimbrite, block and/or ash flow deposits and minor airfall pumice		18_crystalline
Middle Pleistocene igneous rocks	rhyolite	Q7vmr	plagioclase-orthopyroxene± quartz± hornblende rhyolite lava domes and carapace breccia	includes main Maroa complex	18_crystalline
Middle Pleistocene igneous rocks	rhyolite	Q7vor	Rhyolite lava		18_crystalline
Middle Pleistocene igneous rocks	tephra	Q7vp	Rhyolite tepra; includes pumice ash and lapilli; non-welded to highly welded ignimbrite; includes intercalated paleosols		18_crystalline
Middle Pleistocene igneous rocks	rhyolite	Q7vur	Rhyolite lava	Haroharo dome	18_crystalline
Middle Pleistocene river deposits	gravel	Q8a	weathered gravel and sand in alluvial terraces with loess cover	alluvium	06_alluvium
Middle Pleistocene river deposits	gravel	Q8a	Slightly to highly weathered mixtures of gravel/sand/silt/clay forming scattered terrace remnants	Medium-old river alluvium	06_alluvium
Middle Pleistocene river deposits	gravel	Q8a	Weathered clay bound gravel and minor fan deposits forming high aggradation terraces	alluvial deposits	06_alluvium

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Middle Pleistocene river deposits	gravel	Q8a	Weathered, clayey sand and gravel in high terrace remnant on Paddock Hill	Medium-old river alluvium	06_alluvium
Middle Pleistocene river deposits	gravel	Q8a_wd	Slightly to highly weathered mixtures of gravel/sand/silt/clay forming scattered terrace remnants	Medium-old glacial outwash	12_outwash
Middle Pleistocene river deposits	gravel	Q8af	weathered gravel in very dissected fans several metres of loess locally eroded	alluvial fan	10_fan
Middle Pleistocene river deposits	gravel	Q8af	weathered locally derived sandy gravel in high level fans	alluvial fans	10_fan
Middle Pleistocene river deposits	gravel	Q8af	Poorly sorted, weathered steep fan gravel deposits	fan deposits	10_fan
Middle Pleistocene river deposits	gravel	Q8af	Alluvial fan remnants composed of slightly to moderately weathered locally derived silty gravel	alluvial fan	10_fan
Middle Pleistocene river deposits	gravel	Q8al	River gravel and sand often with weathered clasts		06_alluvium
Middle Pleistocene river deposits	gravel	Q8al	weathered greyacke gravels overlain by loess greywacke-schist gravel in terrace remnants in Clutha catchment	alluvial terraces	16_terrace
Middle Pleistocene river deposits	gravel	Q8al	moderately weathered clay-rich sandy gravel in high terraces	alluvial terraces	16_terrace
Middle Pleistocene river deposits	gravel	Q8al	slightly weathered sandy gravel	terrace gravels	16_terrace
Middle Pleistocene river deposits	gravel	Q8al	Weathered, poorly to moderately sorted gravel with minor sand and silt underlying eroded terraces; includes minor fan deposits a	Q8 alluvium over Q9 beach deposits	18_crystalline
Middle Pleistocene river deposits	gravel	Q8al	River gravel and sand often with weathered clasts	alluvial deposits	06_alluvium
Middle Pleistocene river deposits	gravel	Q8al	undifferentiated middle Pleistocene alluvial gravels	alluvium	06_alluvium
Middle Pleistocene river deposits	gravel	Q8al	Weathered, poorly to moderately sorted gravel with minor sand and silt underlying eroded terraces; includes minor fan deposits a	Burnand alluvial terrace deposits	16_terrace
Middle Pleistocene river deposits	gravel	Q8al	Weathered; poorly sorted to moderately sorted gravel underlying loess-covered; commonly eroded aggradational surfaces	Alluvial deposits	06_alluvium

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Middle Pleistocene river deposits	gravel	Q8al	highly weathered, poorly to moderately sorted gravel with loess, sand and silt	alluvium	06_alluvium
Middle Pleistocene river deposits	gravel	Q8al	weathered greyacke gravels overlain by loess; greywacke-schist gravel in terrace remnants in Clutha catchment	alluvial terraces	16_terrace
Middle Pleistocene river deposits	gravel	Q8al_6al	River gravel and sand often with weathered clasts	alluvial deposits	06_alluvium
Middle Pleistocene river deposits	gravel	Q8ao	Slightly to moderately weathered sandy gravel and gravelly sand in outwash remnants	outwash	12_outwash
Middle Pleistocene river deposits	gravel	Q8ao	slightly weathered bouldery to pebbley outwash gravels in terrace remnants	outwash gravel	12_outwash
Middle Pleistocene igneous rocks	ignimbrite	Q8c	Non-welded, poorly-consolidated rhyolite ignimbrite, commonly with nearly aphyric pumice; minor fall deposits		18_crystalline
Middle Pleistocene windblown deposits	loess	Q8e	more than 2 loess layers in upward-building loess-scape away from fluvial influence	loess	11_loess
Middle Pleistocene river deposits	gravel	Q8f	weathered gravel forming high sloping fans	fan	10_fan
Middle Pleistocene river deposits	gravel	Q8f	Slightly to highly weathered mixtures of gravel/sand/silt/clay forming dissected alluvial fan remnants	Medium-old alluvial fan	10_fan
Middle Pleistocene lahar deposits	debris	Q8hi	Bedded sands and conglomerate overlain by laharic andesite breccia	Maitahi Fm over Q9 beach deposit	09_beachBarDune
Middle Pleistocene lahar deposits	debris	Q8hi	Laharic breccia of andesite cobbles overlain in places by well sorted| dune-bedded tephric sand	Katikara dunes over Maitahi Fm	09_beachBarDune
Middle Pleistocene lahar deposits	debris	Q8hi	Laharic breccia of andesite cobbles and boulders, and large rip-up clasts of Tertiary mudstone in a muddy matrix		15_undifSed
Middle Pleistocene lahar deposits	debris	Q8hi	Laharic breccia of andesite cobbles and Tertiary mudstone rip-up clasts in a muddy matrix	Maitahi Fm over Old Fm	15_undifSed
Middle Pleistocene igneous rocks	ignimbrite	Q8ko	silicic ignimbrite, non-welded to eutexitic with fiamme		18_crystalline
Late Pleistocene igneous rocks	ignimbrite	Q8ma	Pink- to purplish-grey, unwelded and soft to welded columnar jointed, locally eutaxitic, rhyolite ignimbrite; minor fall deposi*		18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Pleistocene igneous rocks	ignimbrite	Q8mr	Densely welded silicic ignimbrite; lenticular pumice-rich and crystal rich at top, lithic-rich below.	Millar Road ignimbrite	18_crystalline
Middle Pleistocene igneous rocks	rhyolite	Q8mvr	Rhyolite lava		18_crystalline
Middle Pleistocene river deposits	boulders	Q8o	loose gravel, sand, silt and clay forming outwash plains and traceable upstream to moraine	outwash	12_outwash
Middle Pleistocene igneous rocks	ignimbrite	Q8orl	non-welded to sintered ignimbrite; moderate-low crystal content plagioclase, minor orthopyroxene	lower member	18_crystalline
Middle Pleistocene igneous rocks	ignimbrite	Q8oru	non-welded to sintered ignimbrite; moderate-low crystal content plagioclase, minor orthopyroxene	upper member	18_crystalline
Middle Pleistocene igneous rocks	ignimbrite	Q8pk	Non-welded to slight sintered rhyolite ignimbrite; vapour-phase altered.		18_crystalline
Late Pleistocene igneous rocks	ignimbrite	Q8pp	Rhyolite ignimbrite dominated by lapilli- to block-sized pumice clasts.		18_crystalline
Middle Pleistocene glacier deposits	till	Q8t	Slightly to moderately weathered, sandy to clayey gravel (till) in extensive but subdued moraine topography	till	14_moraineTill
Middle Pleistocene glacier deposits	till	Q8t	Consolidated, slightly weathered, sandy gravel and bouldery till	Medium-old till	14_moraineTill
Middle Pleistocene glacier deposits	gravel	Q8t	Slightly to highly weathered mixtures of gravel/sand/silt/clay forming scattered moraine remnants	Medium-old till	14_moraineTill
Middle Pleistocene glacier deposits	gravel	Q8t	Till often with weathered clasts		14_moraineTill
Middle Pleistocene glacier deposits	gravel	Q8t	Till often with weathered clasts	glacial deposits	14_moraineTill
Middle Pleistocene glacier deposits	till	Q8t	weathered bouldery till	till	14_moraineTill
Middle Pleistocene glacier deposits	gravel	Q8t_pt	Slightly to highly weathered mixtures of gravel/sand/silt/clay forming scattered moraine remnants	Medium-old till	14_moraineTill
Middle Pleistocene glacier deposits	gravel	Q8t_wd	Slightly to highly weathered mixtures of gravel/sand/silt/clay forming scattered moraine remnants	Medium-old till	14_moraineTill

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Middle Pleistocene igneous rocks	rhyolite	Q8vmr	plagioclase-orthopyroxene± quartz± hornblende rhyolite lava domes and carapace breccia	includes main Maroa complex	18_crystalline
Middle Pleistocene river deposits	gravel	Q9al	River gravel and sand usually with cemented clasts		06_alluvium
Middle Pleistocene shoreline deposits	sand	Q9b	sand and gravel	marine terrace deposits	16_terrace
Middle Pleistocene shoreline deposits	sand	Q9b	weathered sand and gravel in dissected terrace remnant several metres of loess locally eroded	alluvial fan	10_fan
Middle Pleistocene shoreline deposits	gravel	Q9b	Beach deposits consisting of marine gravel with sand; commonly underlying loess and fan deposits	beach deposits	09_beachBarDune
Middle Pleistocene shoreline deposits	gravel	Q9b	Slightly to moderately weathered gravel and sand on marine bench remnants between 150 to 220m ASL	marine terrace gravel	16_terrace
Middle Pleistocene shoreline deposits	sand	Q9b	Marine sand and gravel usually with cemented clasts		15_undifSed
Middle Pleistocene shoreline deposits	sand	Q9b	Weathered beach and shallow marine sand, gravel, loess and mud	Brunswick interglacial marine d*	15_undifSed
Middle Pleistocene shoreline deposits	gravel	Q9b	Braemore & Brunswick terrace coverbeds comprising shallow marine conglomerate, shellbeds, dune sands and peat	Braemore & Brunswick marine terrace deposits	16_terrace
Middle Pleistocene shoreline deposits	gravel	Q9b	Slightly to moderately weathered gravel and sand on marine bench remnants between 200 to 240m ASL	marine terrace gravel	16_terrace
Middle Pleistocene shoreline deposits	gravel	Q9b	Slightly to moderately weathered gravel and sand on marine bench remnants; age uncertain, could be Q11 because of higher level	marine terrace gravel	16_terrace
Middle Pleistocene shoreline deposits	gravel	Q9b	Slightly to moderately weathered gravel and sand on marine bench remnants; age uncertain, could be Q7 because of lower level	marine terrace gravel	16_terrace
Middle Pleistocene estuary and shoreline deposits	sandstone	Q9m	pumiceous sandstone, mudstone & conglomerate	shallow marine sediments	05_fluvialEstuarine
Middle Pleistocene igneous rocks	rhyolite	Q9vmr	plagioclase-orthopyroxene± quartz rhyolite lava domes and carapace breccia	includes main Maroa complex	18_crystalline
Middle Pleistocene igneous rocks	rhyolite	Q9vor	Rhyolite lava		18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Middle Pleistocene igneous rocks	ignimbrite	Q9w	Complex sequence of partly welded, crystal-rich ignimbrites.		18_crystalline
Middle Pleistocene igneous rocks	ignimbrite	Q9w	Complex sequence of partly welded, crystal-rich ignimbrites		18_crystalline
Middle Pleistocene igneous rocks	ignimbrite	Q9wh	Complex sequence of partly welded, crystal-rich ignimbrites		18_crystalline
Middle Pleistocene igneous rocks	ignimbrite	Q9wp	Three layered partly welded, crystal-rich ignimbrite formations	Paeroa, Te Kopia and Te Weta mem	18_crystalline
Pleistocene - Holocene river deposits	gravel	Qal	Moderately weathered, poorly to moderately sorted gravel with minor sand and silt underlying terraces; includes minor fan deposi	alluvial terrace deposits	16_terrace
Holocene human-made deposits	boulders	Qan	Reclaimed land with fill consisting of wood domestic waste sand and boulders	anthropic deposits	04_fill
Early Pleistocene - Middle Pleistocene marine deposits	silt	Qbt	Pale grey, fossiliferous, silt or sand with scattered pebbles & boulders (dropstones), massive or laminated, some cross-bedding	Teer Formation	15_undifSed
Pleistocene - Holocene sedimentary rocks	travertine	Qcs	calcareous sinter	sinter	15_undifSed
Pleistocene - Holocene hill slope deposits	unknown	Ql	Unconsolidated to poorly consolidated landslide and rockfall deposits	landslide and rockfall	15_undifSed
Pleistocene - Holocene hill slope deposits	debris	Qls	Earthflow deposits containing poorly sorted clasts up to boulder size in a clay matrix	Landslide and rockfall detritus	15_undifSed
Pleistocene igneous rocks	andesite	Qta	Undifferentiated andesite lava flows exposed north of Mt Tongariro and isolated outcrops in Tongariro River	Undifferentiated Tongariro Subgroup	18_crystalline
Neogene igneous rocks	tephra	Qta	Weathered, clay-rich, multiple tephra deposits of rhyolitic and andesitic origin, and associated paleosols.	Undifferentiated volcanic ash de	18_crystalline
Late Pleistocene - Holocene igneous rocks	basalt	Qval	Grey to very dark grey, dense, fine grained olivine basalt or basanite lava flows.	Auckland volcanic field lava	18_crystalline
Late Pleistocene - Holocene igneous rocks	basalt	Qvas	Red or red-brown to dark grey, poorly-sorted, vesicular, pebble- to boulder-sized ejecta of basaltic or basanitic composition.	Auckland volcanic field scoria	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Pleistocene - Holocene igneous rocks	tuff	Qvat	Lithic tuff, comprising comminuted pre-volcanic materials with basaltic fragments, and unconsolidated ash and lapilli deposits o	Auckland volcanic field ash, lapilli and lithic tuff	18_crystalline
Late Pliocene - Early Pleistocene igneous rocks	basalt	Qvb	Basalt flows	basalt flows	18_crystalline
Middle Pleistocene igneous rocks	dacite	Qvd	Plagioclase-orthopyroxene-clinopyroxene dacite lava, with occasional olivine	[And Awakaponga formation]	18_crystalline
Early Pleistocene sedimentary rocks	volcanic breccia	Qvhb	Debris flow-derived dacite breccia.	Dacite breccia	17_volcanic
Early Pleistocene igneous rocks	dacite	Qvhl	Porphyritic dacite lava flows and dikes.	Dacite lava	18_crystalline
Early Pleistocene igneous rocks	vitric tuff	Qvk	Vitric lapilli tuff and ash tuff dominated by vesicular scoriaceous basalt (olivine nephelinite).		18_crystalline
Early Pleistocene - Late Pleistocene igneous rocks	basalt	Qvkb	Basalt lava and volcanic plugs.	Basalt flows	18_crystalline
Late Pliocene - Early Pleistocene igneous rocks	dacite	Qvkd	Dacite and rhyodacite domes with minor flows and tuff.	Dacite	18_crystalline
Early Pleistocene - Late Pleistocene igneous rocks	scoria	Qvks	Basalt scoria commonly forming steep-sided cones.	Scoria	18_crystalline
Late Pleistocene - Holocene igneous rocks	pyroclastics	Qvmo	Pyroclastic pumice deposits		18_crystalline
Late Pleistocene - Holocene igneous rocks	rhyolite	Qvmt	Peralkaline rhyolite lava flows and domes		18_crystalline
Early Pleistocene - Late Pleistocene igneous rocks	basalt	Qvn	Fine-grained, porphyritic olivine hawaiite lavas, dikes, volcanic breccias and scoria cones.		18_crystalline
Early Pleistocene igneous rocks	basalt	Qvn	Fine-grained porphyritic olivine basalt (hawiite) lava.		18_crystalline
Early Pleistocene - Late Pleistocene igneous rocks	basalt	Qvsl	Fine-grained and coarse-grained, porphyritic, olivine basalt, basanite and hawaiite lava flows.	South Auckland Volcanic field lava	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Early Pleistocene - Late Pleistocene igneous rocks	basalt	Qvss	Red or red-brown to dark grey, poorly-sorted, vesicular, pebble- to boulder-sized ejecta of basaltic, basanitic or hawaiitic com	South Auckland Volcanic field scoria	18_crystalline
Early Pleistocene - Late Pleistocene igneous rocks	tuff	Qvst	Lithic tuff, comprising comminuted pre-volcanic materials with basaltic fragments, and unconsolidated ash and lapilli deposits o	South Auckland Volcanic field ash, lapilli and lithic tuff	18_crystalline
Late Pleistocene igneous rocks	tephra	Qvtp	Rhyolite pyroclastic flow and fall deposits, some hornblende-bearing		18_crystalline
Basement (Western Province) metamorphic rocks	schist	SDpg	deformed quartzite; pelitic; psammitic; calc-psammitic and amphibolitic schist with pegmatite dikes	schist	18_crystalline
Basement (Western Province) metamorphic rocks	schist	SDpgp	deformed Pegasus Group schist with >50% pegmatite dikes	schist	18_crystalline
Basement (Western Province) metamorphic rocks	quartzite	Seh	Thin- to thick-bedded quartzite quartz sandstone and pyritic siltstone	Ellis Group	18_crystalline
Basement (Western Province) metamorphic rocks	paragneiss	Sf	Paragneiss; metabasite; migmatite; gneissic granite; granodiorite; and tonalite; intruded by basaltic	Fraser Complex	18_crystalline
Basement (Western Province) metamorphic rocks	paragneiss	Sf	Paragneiss; metabasite; migmatite; gneissic granite; granodiorite; and tonalite; intruded by basalt and lamprophyre dykes	Fraser Complex	18_crystalline
Basement (Western Province) metamorphic rocks	mylonite	Sfm	Mylonitised gneiss; granitic and granodioritic rocks; metabasite and basaltic dikes	Fraser Complex	18_crystalline
Basement (Western Province) metamorphic rocks	mylonite	Sfm	Mylonitised gneiss; granitic rocks; and dikes	Fraser Complex	18_crystalline
Basement (Eastern Province) sedimentary rocks	greywacke	TJw	Massive to thin bedded, lithic volcaniclastic metasandstone and argillite, with tectonically enclosed spilite, chert and red and		15_undifSed
Basement (Eastern Province) sedimentary rocks	greywacke	TJw	Massive to thin bedded, lithic volcaniclastic metasandstone and argillite, with tectonically enclosed basalt, chert and silceou		15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Allochthonous rocks	greywacke	TJw	Massive to thin bedded, lithic volcaniclastic metasandstone and argillite, with tectonically enclosed basalt, chert and silceou		15_undifSed
Basement (Eastern Province) sedimentary rocks	chert	TJwc	Beds dominated by chert and siliceous argillite.	chert	15_undifSed
Basement (Eastern Province) sedimentary rocks	conglomerate	TJwg	Conglomerate beds.	conglomerate	15_undifSed
Basement (Eastern Province) melange	melange	TJwm	Melange zones	melange	15_undifSed
Basement (Eastern Province) sedimentary rocks	chert	TJwt	Lensoid chert, siliceous argillite and spilite, locally with manganese ore.		15_undifSed
Basement (Eastern Province) igneous rocks	basalt	TJwv	Beds dominated by basaltic lava flows, pillow lavas and volcaniclastics.	basalt	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Ta3a	Dominantly tz 3a pelitic schist; derived from quartzofeldspathic sandstone and mudstone		18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Ta3b4	Dominantly tz 3b-4 pelitic schist; derived from quartzofeldspathic sandstone and mudstone		18_crystalline
Basement (Median Batholith) igneous rocks	diorite	Tab	Hornblende diorite and tonalite.	Buller Diorite	18_crystalline
Basement (Median Batholith) metamorphic rocks	gneiss	Tar	Foliated quartz-feldspar-biotite gneiss.	Rotoiti Gneiss	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Tct3a	Fine grained schist with widespread but thin lenses of greenschist and minor lenses of talcose schist		18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Tct3b4	Fine grained schist with widespread but thin lenses of greenschist and minor lenses of talcose schist		18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Eastern Province) sedimentary rocks	sandstone	Te	Deformed sandstone and/or mudstone dominated sequence with blocks of chert; basalt and limestone; locally melange	Esk Head Belt	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Te	Indurated sandstone & mudstone with minor broken formation and melange; rare basalt, red mudstone, chert & limestone	Esk Head belt	15_undifSed
Basement (Eastern Province) sedimentary rocks	greywacke	Te	Sandstone and mudstone in a sheared argillite matrix with broken formation and melange		15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Te	Indurated sandstone & mudstone with minor broken formation; rare basalt & red mudstone	Esk Head belt	15_undifSed
Basement (Eastern Province) sedimentary rocks	greywacke	Te	sandstone and mudstone in a sheared argillite matrix with broken formation and melange	Torlesse, Esk Head Belt	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Te	Deformed sandstone and/or mudstone dominated sequence with blocks of chert; basalt and limestone; locally melange	Esk Head belt	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Te	Thick; poorly bedded sandstone; minor mudstone minor broken formation and melange	Esk Head belt	15_undifSed
Basement (Eastern Province) melange	melange	Tem	Deformed bedded sandstone & mudstone, commonly as broken fmn or melange with exotic blocks of basalt, chert, red mst & limestone	Esk Head melange	15_undifSed
Basement (Eastern Province) melange	sandstone	Tem	Deformed sandstone; minor mudstone; coloured mudstone; limestone; and basalt commonly as broken formation or melange	Esk Head belt	15_undifSed
Basement (Eastern Province) melange	sandstone	Tem	Deformed bedded sandstone & mudstone, commonly as broken fmn or melange with exotic blocks of basalt, chert, red mst & limestone	Esk Head belt	15_undifSed
Basement (Eastern Province) sedimentary rocks	chert	Tet	Chert		15_undifSed
Basement (Eastern Province) igneous rocks	basalt	Tev	Basalt	Esk Head Belt	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Eastern Province) igneous rocks	basalt	Tev	Basalt as flows and rarely with pillow form, commonly occuring with coloured mudstone and altered tuff.	Esk Head belt	18_crystalline
Basement (Eastern Province) igneous rocks	basalt	Tev	small to large blocks of basalt within melange zones	volcanics in the Esk Head Belt	18_crystalline
Basement (Median Batholith) igneous rocks	diorite	Tgo	Diorite intruded by fine grained granite; minor hornblende segregations; rafts of gneissic granite and biotite gneiss	diorite	18_crystalline
Basement (Median Batholith) metamorphic rocks	diorite	Tgo	Variably foliated & altered diorite, leucodiorite, trondjemite &granitic orthogneiss; pervasively intruded by Darran Leucogabbro	diorite	18_crystalline
Basement (Median Batholith) igneous rocks	diorite	Tgo	Relatively fine grained diorite; gabbronorite; trondhjemite gneiss in the north of polygon with sparse garnet	diorite	18_crystalline
Basement (Median Batholith) metamorphic rocks	granite	Tgo	Granitic to biotite orthogneiss; variably foliated & altered diorite & trondjemite; pervasively intruded by Darran Leucogabbro	granite	18_crystalline
Basement (Median Batholith) metamorphic rocks	paragneiss	Tgp	Quartz-plagioclase-orthoclase-biotite-garnet paragneiss; gneissic metasandstone; pegmatite; granitoid dikes; minor diorite	paragneiss	18_crystalline
Basement (Median Batholith) metamorphic rocks	paragneiss	Tgp	Quartz-plagioclase-orthoclase-biotite-garnet paragneiss; muscovite-biotite gneiss; pegmatite; granitoid dikes; minor diorite	paragneiss	18_crystalline
Basement (Median Batholith) igneous rocks	diorite	Thb	undifferentiated diorite; monzodiorite; granodiorite; rare syenogranite and monzogranite	intrusives	18_crystalline
Basement (Median Batholith) igneous rocks	monzodiorite	Thba	foliated quartz monzodiorite with abundant xenoliths	diorite	18_crystalline
Basement (Median Batholith) igneous rocks	diorite	Thbd	predominantly meladiorite	diorite	18_crystalline
Basement (Median Batholith) igneous rocks	gneiss	Thbg	quartz-biotite-epidote gneiss derived from Holly Burn Intrusives	gneiss	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Median Batholith) igneous rocks	quartz diorite	Thbq	predominantly quartz diorite	quartz diorite	18_crystalline
Basement (Median Batholith) igneous rocks	diorite	Ti	Variably foliated diorite, granite, & trondhjemite, with microdiorite & pegmatite dikes; variably altered	gneissic diorite	18_crystalline
Basement (Median Batholith) igneous rocks	trondhjemite	Ti	Fault bounded body of trondhjemite intruded by dikes and includes rafts of biotite gneiss	gneissic diorite	18_crystalline
Basement (Median Batholith) igneous rocks	quartz diorite	Tid	Altered medium grained biotite-hornblende quartz diorite with minor clinopyroxene; strongly foliated along western margin	quartz diorite	18_crystalline
Basement (Median Batholith) igneous rocks	granite	Tih	Dominantly leucogranite and granite; minor microdiorite dikes and xenoliths; quartz diorite locally abundant in Hut Creek	granite	18_crystalline
Basement (Median Batholith) igneous rocks	quartz diorite	Tim	Massive, medium to coarse, biotite-augite quartz diorite & biotite-hornblende granite; widespread greenschist facies alteration	quartz diorite	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	Tir	Altered and variably foliated granodiorite	granodiorite	18_crystalline
Basement (Eastern Province) melange	melange	Tmc	Mafic and ultramafic igneous rocks and sedimentary rocks in a sheared serpentinite matrix		15_undifSed
Basement (Eastern Province) melange	melange	Tmc	Mafic and ultramafic igneous and sedimentary rocks in a sheared serpentinite matrix	Croisilles Melange	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tmg	Thinly bedded grey sandstone; siltstone; and mudstone with thick green sandstone. Minor siltstone and conglomerate	Greville Formation	15_undifSed
Basement (Eastern Province) sedimentary rocks	mudstone	Tmg	Grey laminated slaty mudstone, siltstone and siltstone; graded bedding common	Greville Formation	15_undifSed
Basement (Eastern Province) sedimentary rocks	siltstone	Tmg	thin bedded siltstone and sandstone with minor limestone and conglomerate	siltstone	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Eastern Province) sedimentary rocks	sandstone	Tmg	Laminated to thin-bedded grey sandstone, mudstone and siltstone with local tuffs and sparse ammonites	Maitai sandstone	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tmg	Finely bedded sandstone and siltstone with thick sandstone lenses sparse ammonoids	Greville Formation	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tmg	Thinly bedded grey sandstone; siltstone; and mudstone with thick green sandstone. Minor siltstone and conglomerate		15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tmgs	Green sandstone		15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tml	Dm to m, hard, green, fine to coarse grained volcaniclastic sandstone with yellow-green mudstone chips;minor siltstone & breccia	Maitai sandstone	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tml	red and green sandstone with subordinate siltstone and rare granule conglomerate	sandstone	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tml	Thick bedded (dm-m) to massive green volcanogenic sandstone with scattered yellow-green siltstone chips, minor siltstone & slate	Little Ben Sandstone	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tml	Bedded sandstone with minor siltstone	Little Ben Sandstone	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tml	Poorly bedded green volcanogenic sandstone		15_undifSed
Basement (Eastern Province) sedimentary rocks	volcanic sandstone	Tml	Dm-m bedded, hard, green, fine to coarse grained volcaniclastic sandstone with yellow-green mst chips; minor siltstone & breccia	Maitai sandstone	17_volcanic
Basement (Eastern Province) igneous rocks	serpentinite	Tmm	Serpentinite breccia	melange	18_crystalline
Basement (Eastern Province) melange	melange	Tmp	Mafic and ultramafic igneous rocks and sedimentary rocks in a sheared serpentinite matrix		15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Eastern Province) melange	melange	Tmp	Mafic and ultramafic igneous and sedimentary rocks in a sheared serpentinite matrix	Patuki Melange	15_undifSed
Basement (Eastern Province) sedimentary rocks	siltstone	Tms	siltstone; conspicuous sandstone bands; minor conglomerate and limestone; and red and green siltstone	siltstone	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tms	Variably bedded; dominantly green and grey sandstone-siltstone with conglomerate lenses and sparse fossiliferous sandstone		15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tms	Variably bedded sandstone, red sandstone-siltstone sequences, conglomerate-breccia lenses, and conspicous tuffs	Maitai sandstone	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tms	Variably bedded sandstone-siltstone with conglomerate lenses and limestone blocks locally fossiliferous	Stephens Formation	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tms	Massive green volcanogenic sandstone with yellow siltstone/tuff clasts; minor interbedded siltstone-mudstone,tuff & conglomerate	Stephens Subgroup	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tms	sandstone with subordinate siltstone conglomerate and tuff	sandstone	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tms	Variably bedded; dominantly green and grey sandstone-siltstone with conglomerate lenses and sparse fossiliferous sandstone	Stephens Subgroup	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tmw	Purple grey and green finely laminated sandstone and siltstone (mudstone); horizons of massive green volcanogenic sandstone	Waiua Formation	15_undifSed
Basement (Eastern Province) sedimentary rocks	siltstone	Tmw	red and grey siltstone with subordinate sandstone and conglomerate	siltstone	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tmw	Finely bedded green sandstone and red siltstone	Waiua Formation	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tmw	Thin to thick bedded red volcanic sandstone; hematitic and laminated red and green siltstone; red and green breccia-sst lenses	Maitai sandstone	15_undifSed

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Basement (Eastern Province) sedimentary rocks	sandstone	Tmw	Thinly bedded green sandstone; and red siltstone and mudstone		15_undifSed
Basement (Eastern Province) sedimentary rocks	siltstone	Tn	Fossiliferous siltstone with interbedded fine to coarse sandstone and thin tuff beds; common zeolite veins.	Newcastle Group (Late Triassic)	15_undifSed
Basement (Western Province) sedimentary rocks	sandstone	Top	Volcaniclastic sandstone with minor conglomerate	Topfer Formation	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tp	Well-poorly bedded sandstone-siltstone and semi-schist to east; predominantly pelitic well foliated laminated schist to west		15_undifSed
Basement (Eastern Province) metamorphic rocks	sandstone	Tp	Well-poorly bedded sandstone-siltstone and semi-schist to east; predominantly pelitic well foliated laminated schist to west		18_crystalline
Basement (Eastern Province) metamorphic rocks	sandstone	Tp2a	Tz 2a; weakly to moderately foliated		18_crystalline
Basement (Eastern Province) metamorphic rocks	sandstone	Tp2b	Tz 2b; strongly foliated		18_crystalline
Basement (Eastern Province) metamorphic rocks	sandstone	Tp3a	Tz 3a; strongly foliated; incipient segregation laminae		18_crystalline
Basement (Eastern Province) metamorphic rocks	sandstone	Tp3b4	Tz 3b-4; strongly foliated; well developed segregation laminae		18_crystalline
Basement (Eastern Province) sedimentary rocks	conglomerate	Tr	Conglomerate and sandstone; minor siltstone; locally stained red		15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tr	Variably bedded sandstone- siltstone with conglomerate containing granite clasts. Commonly tuffaceous and fossiliferous	Richmond Group	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Trb	Well-bedded sparsely, fossiliferous sandstone and siltstone with tuffaceous horizons and conglomerate beds.	Blue Glen Formation	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Eastern Province) sedimentary rocks	sandstone	Tt	Alternating sandstone and mudstone; poorly bedded sandstone with minor coloured mudstone; conglomerate; basalt; chert		15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tt	Alternating sandstone and mudstone; poorly bedded sandstone with minor coloured mudstone; conglomerate; basalt; chert	Rakaia terrane	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tt	Thick; poorly bedded sandstone; and well bedded alternating sandstone/mudstone; coloured mudstone; locally as broken fm	Rakaia terrane	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tt1	Well indurated; greywacke sandstone interbedded w argillitic mudstone/zst; minor congl/red mst/lst/chert/mafic volcanics; TZ1	Torlesse TZ1 greywacke	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tt1	Well indurated, massive or bedded, greywacke sandstone & argillitic mudstone/siltstone; minor conglomerate/chert/volcanics; TZ1	Rakaia TZ1 greywacke	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tt1	Well indurated, massive or bedded, sandstone & siltstone (greywacke) with subordinate mudstone and chert. TZ1	Rakaia TZ1 greywacke	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tt1	Well indurated; greywacke sandstone; argillitic mudstone/siltstone; minor conglomerate/tuffaceous sandstone/volcanics; TZ1	Torlesse TZ1 greywacke	15_undifSed
Basement (Eastern Province) sedimentary rocks	greywacke	Tt1	quartzofeldspathic sandstone (greywacke) interbedded with mudstone (argillite)		15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tt1_b	Bedded sandstone/dark siltstone; red siltstone; greywacke conglomerate lenses; rare plant fossils; zeolite/quartz veins; TZ1	Torlesse TZ1 Balmacaan sst/zst	15_undifSed
Basement (Eastern Province) sedimentary rocks	siltstone	Tt1_cys	Cleaved; massive dark grey fossiliferous siltstone; poorly bedded; isolated beds of sandstone and calcareous concretions; TZ1	Torlesse TZ1 Carneys Ck siltst	15_undifSed
Basement (Eastern Province) sedimentary rocks	siltstone	Tt1_es	Alternating massive blocky siltstone & light grey sandstone; upward-fining graded bedding; shellbeds; TZ1	Torlesse TZ1 Erewhon zst/sst	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tt1_f	Sandstone with cannonball concretions; thin-bedded dark sandstone and black siltstone with cross-laminated & graded bedding; TZ1	Torlesse TZ1 Fingers sst/zst	15_undifSed

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Basement (Eastern Province) sedimentary rocks	siltstone	Tt1_fs	Thinly bedded siltstone with minor sandstone channels; internal lamination/ripples; commonly disrupted/folded; TZ1	Torlesse TZ1 Fingers bdd zst	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tt1_k	Undifferentiated greywacke/argillite in Winterslow Range; locally slightly schistose; TZ1	Torlesse TZ1 Taylor greywacke	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tt1_m	Thin-bedded sandst/siltstone flysch; minor black mudstone+red argillite+conglomerate; plant fragments; Torlessia; TZ1	Torlesse TZ1 thin-bedded sst/zst	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tt1_n	Hard; massive greywacke sandstone with concretions+conglomerate+mudstone clasts; minor thin-bedded sandstone/siltstone; TZ1	Torlesse TZ1 massive sandst	15_undifSed
Basement (Eastern Province) sedimentary rocks	siltstone	Tt1_ns	Grey siltstone; thin beds of disarticulated bivalves and some brachiopods; TZ1	Torlesse TZ1 Nowhere zst/sst	15_undifSed
Basement (Eastern Province) sedimentary rocks	siltstone	Tt1_p	Thickly-bedded (beds>10m) greywacke sandstone/black argillitic siltstone (50:50); minor conglomerate & plant fragments; TZ1	Torlesse TZ1 thick-bdd zst/sst	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tt1_ph	Interbedded greywacke sandstone & argillitic siltstone; cross-laminated and graded bedding; common Torlessia mackayi; TZ1	Torlesse TZ1 PuddingHill sst/mst	15_undifSed
Basement (Eastern Province) sedimentary rocks	siltstone	Tt1_s	Thin-bedded siltstone with minor sandstone channels; parallel & ripple lamination; commonly disrupted/folded; TZ1	Torlesse TZ1 thin-bedded siltst	15_undifSed
Basement (Eastern Province) sedimentary rocks	siltstone	Tt1_tgc	Carbonaceous mudstone; siltstone; orange or purple sandstone; very thin anthracite coal seams; TZ1	Torlesse TZ1 Tank Gully CM	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Tt1_tgn	Grey sandstone; mudstone chip/sandstone pebble conglomerate; siltstone; carbonaceous siltstone; plant beds; TZ1	Torlesse TZ1 Potts Bench sst	15_undifSed
Basement (Eastern Province) sedimentary rocks	cataclasite	Tt1_x	Variably crushed/brecciated TZ1 greywacke sandstone & argillitic mudstone; clayey pug zones	Torlesse TZ1 crush zone	15_undifSed
Basement (Eastern Province) metamorphic rocks	greywacke	Tt2a	weakly foliated quartzofeldspathic sandstone (greywacke) interbedded with mudstone (argillite)		18_crystalline

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Basement (Eastern Province) metamorphic rocks	sandstone	Tt2a	Weakly to moderately foliated		18_crystalline
Basement (Eastern Province) metamorphic rocks	semischist	Tt2a	Thick poorly bedded sandstone and well bedded alternating sandstone/mudstone with incipient-prominent cleavage	Rakaia terrane	18_crystalline
Basement (Eastern Province) metamorphic rocks	sandstone	Tt2a	Weakly foliated or cleaved greywacke & argillitc mst (semischist); minor conglomerate,metachert,mafic metavolcanics,red mst;TZ2A	Torlesse TZ2A semischist	18_crystalline
Basement (Eastern Province) metamorphic rocks	sandstone	Tt2a	Slightly foliated or cleaved; greywacke sandstone and argillitic mudstone; low-grade metatuff and metachert; TZ2A	Torlesse TZ2A semischist	18_crystalline
Basement (Eastern Province) metamorphic rocks	sandstone	Tt2a_m	Slightly foliated; thinly bedded schistose sandstone/siltstone; TZ IIA	Torlesse TZ2A thin-bdd sst/mst	18_crystalline
Basement (Eastern Province) metamorphic rocks	sandstone	Tt2a_n	Slightly cleaved; hard; massive greywacke sandstone; minor thin-bedded sandstone/siltsone;TZ2A	Torlesse TZ2A massive sandst	18_crystalline
Basement (Eastern Province) metamorphic rocks	siltstone	Tt2a_s	Slightly foliated or cleaved; thin-bedded siltstone & minor sandstone channels; commonly disrupted/folded; TZ2A	Torlesse TZ2A thin-bedded siltst	18_crystalline
Basement (Eastern Province) metamorphic rocks	semischist	Tt2b	Semischistose sandstone and mudstone; moderately-strongly transposed with well developed cleavage/foliation; locally folded	Rakaia terrane	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Tt2b	moderately foliated quartzofeldspathic semischist interbedded with argillite		18_crystalline
Basement (Eastern Province) metamorphic rocks	semischist	Tt2b	Planar-foliated; low-grade psammitic/pelitic semischist; minor low-grade metatuff and metachert; TZ2B	Torlesse TZ2B semischist	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Tt3	Prominently planar-foliated; psammitic/pelitic schist; TZ3	Torlesse TZ3 schist	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Tt3	Schist derived from quartzofeldspathic sandstone and mudstone	Rakaia terrane	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Eastern Province) metamorphic rocks	schist	Tt3a	Dominantly pelitic schist derived from quartzo-feldspathic sandstone-mudstone	Torlesse Supergroup	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Tt3b4	Dominantly pelitic schist derived from quartzo-feldspathic sandstone-mudstone	Torlesse Supergroup	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Tt4	Schist derived from quartzofeldspathic sandstone and mudstone	Rakaia terrane	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Tt4	Prominently segregated high-grade schist; cm-scale quartz-albite segregations; rare greenschist and metachert; TZ4	Torlesse TZ4 schist	18_crystalline
Basement (Eastern Province) sedimentary rocks	mudstone	Tta	mudstone (argillite) dominated units within TZ1 sandstone-mudstone sequence	Torlesse TZ1 argillite	15_undifSed
Basement (Eastern Province) sedimentary rocks	greywacke	Ttc	Marine sandstone and siltstone grading up to non-marine carbonaceous sand, silt and coal		15_undifSed
Basement (Eastern Province) metamorphic rocks	metaconglomerate	Ttc2a	Weakly foliated metaconglomerate and schist	Rakaia terrane	18_crystalline
Basement (Eastern Province) metamorphic rocks	metaconglomerate	Ttc2b	Schistose metaconglomerate and schist	Rakaia terrane	18_crystalline
Basement (Eastern Province) metamorphic rocks	metaconglomerate	Ttc3	Weakly foliated metaconglomerate and schist	Rakaia terrane	18_crystalline
Basement (Eastern Province) sedimentary rocks	breccia	Ttcz	Crush zone; large areas of crushed and sheared red&green mudstone, chert, greywacke sandstone & argillitic mst; clayey pug zones	Rakaia crush zone	15_undifSed
Basement (Eastern Province) sedimentary rocks	breccia	Ttcz	Crush zone; large areas of crushed and sheared greywacke sandstone and mudstone along faults; clayey pug zones	Rakaia crush zone	15_undifSed
Basement (Eastern Province) sedimentary rocks	greywacke	Tth	massive sandstone with lesser mud-chip conglomerate and graded sandstone/siltstone units; homogeneous concretionary black siltst		15_undifSed

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Basement (Eastern Province) sedimentary rocks	limestone	Ttl	Limestone		15_undifSed
Basement (Eastern Province) sedimentary rocks	greywacke	Ttm	Unfoliated to weakly foliated sandstone, siltstone, shale and conglomerate with shellbeds		15_undifSed
Basement (Eastern Province) melange	sandstone	Ttm	Deformed sandstone, mudstone, coloured mudstone, chert, and basalt occurring in broken formation and melange	Rakaia terrane	15_undifSed
Basement (Eastern Province) metamorphic rocks	greywacke	Ttm2a	Unfoliated to weakly foliated sandstone, siltstone, shale and conglomerate with shellbeds		18_crystalline
Basement (Eastern Province) sedimentary rocks	greywacke	Tto	Thick bedded marine sandstone and rhythmically bedded siltstone and shale		15_undifSed
Basement (Eastern Province) sedimentary rocks	conglomerate	Ttoc	non-marine conglomerate with interbedded shale; basal part of Otematata Group		15_undifSed
Basement (Eastern Province) sedimentary rocks	chert	Ttt	Chert		15_undifSed
Basement (Eastern Province) sedimentary rocks	mudstone	Ttv	Thin to thick bedded coloured mudstone; minor basalt; with alternating sandstone and mudstone; locally as broken formation	Rakaia terrane	15_undifSed
Basement (Eastern Province) igneous rocks	basalt	Ttv	Basalt		18_crystalline
Basement (Eastern Province) igneous rocks	metavolcanics	Ttv	Basaltic metavolcanics; chert; red and green mudstone	Rakaia metavolcanics	18_crystalline
Basement (Eastern Province) sedimentary rocks	mudstone	Ttv	Basalt as flows and rarely with pillow form, commonly occuring with coloured mudstone and altered tuff.	Rakaia terrane	15_undifSed
Basement (Median Batholith) metamorphic rocks	gneiss	Twg	Variably mylonitised biotite-garnet gneiss, gneissic biotite granite, and minor amphibolite with marble lenses; rare mafic dikes	granite gneiss	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Eastern Province) metamorphic rocks	mylonite	YTm	Schist-derived mylonite; cataclasite; and fault breccia close to the Alpine Fault		18_crystalline
Basement (Eastern Province) metamorphic rocks	mylonite	YTm	Schist-derived mylonite; curly schist; cataclasite; fault breccia near Alpine Fault trace; some amphibolite/chert/pegmatite; TZ4	Torlesse mylonite	18_crystalline
Basement (Eastern Province) metamorphic rocks	mylonite	YTm	Schist-derived mylonite; curly schist; cataclasite; fault breccia near Alpine Fault trace; some amphibolite & chert; TZ4	Torlesse mylonite	18_crystalline
Basement (Eastern Province) metamorphic rocks	mylonite	YTm	Schist-derived mylonite; curly schist; cataclasite; & fault breccia near the Alpine Fault; some greenschist/chert/pegmatite; TZ4	Torlesse Aspiring mylonite	18_crystalline
Basement (Eastern Province) sedimentary rocks	siltstone	YTm	siltstone; conspicuous sandstone bands; minor conglomerate and limestone; and red and green siltstone	siltstone	15_undifSed
Basement (Eastern Province) metamorphic rocks	amphibolite	YTma	Mylonitised amphibolite, quartzofeldspathic schist, quartz-mica schist, and minor calc-schist; some kyanite-bearing assemblages	Torlesse amphibolitic mylonite	18_crystalline
Basement (Western Province) metamorphic rocks	paragneiss	YTrms	Migmatitic (semi-) pelitic schist & gneiss; locally quartzofeldspathic, quartzitic, & amphibolitic gneiss; rare calc-silicate	metasediment	18_crystalline
Basement (Eastern Province) sedimentary rocks	sandstone	YTt1	Well indurated, massive or bedded, greywacke sandstone & argillitic mudstone/siltstone; minor conglomerate/chert/volcanics; TZ1	Rakaia TZ1 greywacke	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	YTt1	Well indurated; greywacke sandstone; argillitic mudstone/siltstone; minor conglomerate/tuffaceous sandstone/volcanics; TZ 1	Torlesse TZ1 greywacke	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	YTt1_n	Hard; massive greywacke sandstone with concretions+conglomerate+mudstone clasts; minor thin-bedded sandstone/siltstone; TZ1	Torlesse TZ1 massive sandst	15_undifSed
Basement (Eastern Province) sedimentary rocks	siltstone	YTt1_s	Thin-bedded siltstone with minor sandstone channels; parallel & ripple lamination; commonly disrupted/folded; TZ1	Torlesse TZ1 thin-bedded siltst	15_undifSed
Basement (Eastern Province) metamorphic rocks	sandstone	YTt2a	Slightly foliated; weakly-cleaved greywacke sandstone and argillitic mudstone; low-grade metatuff and metachert; TZ2A	Torlesse TZ2A semischist	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Eastern Province) melange	melange	YTtm	Basaltic metavolcanics; limestone; red & green mst, chert assoc with deformed sandstone & mudstone (broken formation) in melange	Rakaia melange	15_undifSed
Basement (Eastern Province) metamorphic rocks	semischist	Ya2b	Semischistose sandstone and mudstone moderately-strongly transposed with well developed cleavage or foliation; locally folded	Aspiring lithological assoc.	18_crystalline
Basement (Eastern Province) metamorphic rocks	semischist	Ya2b	Planar-foliated; low-grade psammitic/pelitic semischist; minor low-grade metatuff and metachert; TZ2B	Torlesse Aspiring TZ2B semisch	18_crystalline
Basement (Eastern Province) metamorphic rocks	pelite	Ya3	Planar foliated and laminated pelitic and subordinate psammitic greyschist; minor greenschist and metachert; TZ3	Torlesse Aspiring TZ3 schist	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Ya3	Prominently planar-foliated; psammitic/pelitic schist; subordinate greenschist layers; TZ3	Torlesse Aspiring TZ3 schist	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Ya3	Incipiently segregated schist derived from quartzofeldspathic sandstone and mudstone; greenschist and metachert	Aspiring lithological assoc.	18_crystalline
Basement (Eastern Province) metamorphic rocks	pelite	Ya4	Very well segregated &laminated; abundant pelitic & subordinate psammitic greyschist & gneiss;minor gs-amphibolite&metachert;TZ4	Torlesse Aspiring TZ4 schist	18_crystalline
Basement (Eastern Province) metamorphic rocks	pelite	Ya4	Very well segregated and laminated; abundant pelitic & subordinate psammitic greyschist; minor greenschist & metachert; TZ4	Torlesse Aspiring TZ4 schist	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Ya4	Prominently segregated schist; cm-scale quartz-albite segregations; abundant pelitic schist; greenschist/metachert common; TZ4	Torlesse Aspiring TZ4 schist	18_crystalline
Basement (Eastern Province) metamorphic rocks	pelite	Ya4	Very well segregated &laminated; abundant pelitic & subordinate psammitic greyschist;minor greenschist/amphibolite&metachert;TZ4	Torlesse Aspiring TZ4 schist	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Ya4	Well segregated schist derived from quartzofeldspathic sandstone and mudstone; greenschist and metachert	Aspiring lithological assoc.	18_crystalline
Basement (Eastern Province) metamorphic rocks	pelite	Ya4	Very well segregated & laminated; abundant pelitic & subordinate psammitic greyschist & gneiss;minor amphibolite & metachert;TZ4	Torlesse Aspiring TZ4 schist	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Eastern Province) metamorphic rocks	pelite	Yab4	Abundant porphyroblastic, poorly foliated, pelitic schist with subord psammitic greyschist; minor greenschist & metachert; TZ4	Aspiring TZ4porphyroblast schist	18_crystalline
Basement (Eastern Province) metamorphic rocks	greenschist	Yag3	Abundant (>10%) greenschist bands in mainly pelitic & minor psammitic greyschist, minor metachert & marble; TZ3	Aspiring TZ3 greenschist	18_crystalline
Basement (Eastern Province) metamorphic rocks	greenschist	Yag4	Abundant (>10%) greenschist bands in mainly pelitic & minor psammitic greyschist, minor metachert & marble; TZ4	Aspiring TZ4 greenschist	18_crystalline
Basement (Eastern Province) metamorphic rocks	greenschist	Yag4	Abundant epidote- to chlorite-rich greenschist with metachert bands; pelitic and psammitic schist; rare marble; TZ4	Aspiring TZ4 greenschist	18_crystalline
Basement (Eastern Province) metamorphic rocks	greenschist	Yag4	Abundant (>10%) greenschist/?amphibolite bands in mainly pelitic & minor psammitic greyschist, minor metachert & marble; TZ4	Aspiring TZ4 greenschist	18_crystalline
Basement (Eastern Province) metamorphic rocks	amphibolite	Yag4	Abundant (>10%) amphibolite bands in mainly pelitic & minor psammitic greyschist, minor metachert & marble; TZ4	Aspiring TZ4 greenschist	18_crystalline
Basement (Eastern Province) metamorphic rocks	greenschist	Yag4	Abundant (>10%) greenschist/amphibolite bands in mainly pelitic & minor psammitic greyschist, minor metachert & marble; TZ4	Aspiring TZ4 greenschist	18_crystalline
Basement (Eastern Province) metamorphic rocks	pelite	Yai4	Abundant laminated pelitic greyschist and subordinate psammitic greyschist; minor greenschist & metachert; TZ4	Torlesse Aspiring TZ4 schist	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Yam4	Interlayered psammitic and pelitic greyschist; minor greenschist; TZ4	Torlesse Aspiring TZ4 schist	18_crystalline
Basement (Eastern Province) metamorphic rocks	psammite	Yan4	Laminated psammitic greyschist and subordinate pelitic schist; rare greenschist; TZ4	Torlesse Aspiring TZ4 schist	18_crystalline
Basement (Eastern Province) metamorphic rocks	serpentinite	Yap	Serpentinite; metagabbro; polymict igneous breccia; metabasite/talc-greenschist; Locally felted into metasomatic nephrite	Torlesse Aspiring Pounamu UM	18_crystalline
Basement (Eastern Province) metamorphic rocks	serpentinite	Yau2b	Serpentinite and gabbro; metamorphosed with metasedimentary semischist	Pounamu Ultramafics	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Eastern Province) metamorphic rocks	serpentinite	Yau3	Serpentinite and gabbro; metamorphosed with pelitic; psammitic and metabasite schist	Pounamu Ultramafics	18_crystalline
Basement (Eastern Province) metamorphic rocks	serpentinite	Yau4	Serpentinite and gabbro; metamorphosed with pelitic; psammitic and metabasite schist	Pounamu Ultramafics	18_crystalline
Basement (Eastern Province) igneous rocks	basalt	Yb	Undifferentiated mafic volcanic flows, interbedded tuff, volcaniclastic sandstone and siltstone, and breccia	undiff. Brook Street Volcanics G	18_crystalline
Basement (Eastern Province) igneous rocks	mylonite	Yb	strongly strained & locally mylonitic gabbro, dolerite, amphibolite, diorite, granite, schist & ultramafic rocks	Brook Street Volcanics undiff	18_crystalline
Basement (Eastern Province) igneous rocks	gabbro	Ybb	Coarse, altered, pervasively sheared gabbro intrusion; serpentinitised along faulted margins of intrusion	gabbro	18_crystalline
Basement (Eastern Province) igneous rocks	basalt	Ybb	Basalt, dolerite, minor gabbro and interbedded tuff.	Brough Formation	18_crystalline
Basement (Eastern Province) igneous rocks	diorite	Ybbidhz	intrusion zone of diorite to tonalite with abundant hornfels xenoliths	diorite	18_crystalline
Basement (Eastern Province) igneous rocks	dunite	Ybbidz		dunite	18_crystalline
Basement (Eastern Province) igneous rocks	gabbro	Ybbigoz	massive gabbro and norite	gabbro	18_crystalline
Basement (Eastern Province) igneous rocks	norite	Ybbigoz	norite; with wide metasomatic marginal zone	gabbro	18_crystalline
Basement (Eastern Province) igneous rocks	granodiorite	Ybbigrz	granodiorite	granodiorite	18_crystalline
Basement (Eastern Province) igneous rocks	tonalite	Ybbitoz	tonalite; quartz diorite and diorite	tonalite	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Eastern Province) sedimentary rocks	sandstone	Ybc	Pale green to grey, bedded feldspathic sandstone, siltstone, and minor mudstone	volcaniclastics	15_undifSed
Basement (Eastern Province) sedimentary rocks	volcanic sandstone	Ybd	Medium to dark green volcaniclastic sandstone with thick beds & lenses of volcanic breccia; siltstone in upper part of fmn	volcaniclastics	17_volcanic
Basement (Eastern Province) sedimentary rocks	volcanic sandstone	Ybe	Green-grey volcaniclastic sandstone & breccia; tuff; many andesitic, basaltic & microdiorite dikes & lava flows; minor siltstone	volcaniclastic sediments	17_volcanic
Basement (Eastern Province) sedimentary rocks	volcanic sandstone	Ybe	foliated, andesite-derived, red & green volcaniclastic sandstone, congl & breccia; intruded by basalt & andesite dikes & sills	Eglinton Subgroup	17_volcanic
Basement (Eastern Province) sedimentary rocks	mudstone	Ybem	Red and green mudstone with minor breccia bands; rare impure limestone, a few dikes	mudstone	15_undifSed
Basement (Eastern Province) sedimentary rocks	volcanic breccia	Yber	Volcaniclastic breccia & sandstone; rare fossiliferous limestone; andesitic, microdiorite, & microgabbro dikes	breccia	17_volcanic
Basement (Eastern Province) sedimentary rocks	sandstone	Ybf	Massive to well bedded greyish-green to grey feldspathic sandstone	volcaniclastics	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Ybg	Massive to bedded tuffaceous sandstone and siltstone		15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Ybg	Massive to bedded tuffaceous sandstone and siltstone	Groom Creek Formation	15_undifSed
Basement (Eastern Province) igneous rocks	tuff	Ybg	Well- to poorly-bedded tuff	Groom Creek Formation	18_crystalline
Basement (Eastern Province) igneous rocks	pyroxenite	Ybh	Coarse grained pyroxenite, metabasic, meta-andesitic, & aphyric dike and sill swarm in rare schistose to epidioritic host	metabasics	18_crystalline
Basement (Eastern Province) igneous rocks	trondhjemite	Ybi	Massive, coarse grained trondhjemite with enclaves of Skippers Subgroup amphibolite and Mantle Volcanics	trondhjemite	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Eastern Province) sedimentary rocks	breccia	Ybk	Coarse augite breccia and tuff minor basalt	Kaka Formation	15_undifSed
Basement (Eastern Province) sedimentary rocks	breccia	Ybk	Green augite-rich basaltic breccia; tuff and basalt		15_undifSed
Basement (Eastern Province) sedimentary rocks	breccia	Ybk	Green augite-rich basaltic breccia; tuff and basalt	Kaka Formation	15_undifSed
Basement (Eastern Province) igneous rocks	pyroclastic breccia	Ybm	Basaltic to andesitic pyroclastic breccia & congl, crystal-lithic tuff, and lava flows; minor siltstone & sst; mafic dikes+sills	volcanics	18_crystalline
Basement (Eastern Province) igneous rocks	dolerite	Ybn	Strongly altered, dark, medium to coarse, augite-rich dolerite	dolerite	18_crystalline
Basement (Eastern Province) igneous rocks	serpentinite	Ybo	serpentinite with rodingite dikes; minor gabbro; pyroxenite; gabbronorite; diorite and basalt		18_crystalline
Basement (Eastern Province) metamorphic rocks	greenschist	Ybp	Metamorphosed and schistose green to grey tuffs and andesitic sandstones; magnesian schists; amphibolite pods; greyschists	greenschist	18_crystalline
Basement (Eastern Province) igneous rocks	trondhjemite	Ybptj	trondhjemite; leuco-tonalite	trondhjemite	18_crystalline
Basement (Eastern Province) igneous rocks	pyroclastic breccia	Ybq	Pyroclastic breccia, agglomerate, lapilli tuff, and green (sometimes red) volcaniclastic sandstone	volcaniclastics	18_crystalline
Basement (Eastern Province) sedimentary rocks	sandstone	Ybr	Bedded sandstone commonly tuffaceous and calcareous minor sandstone and breccia sparse fossils	Grampian Formation	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Ybr	Well bedded tuffaceous grey sandstone and siltstone		15_undifSed
Basement (Eastern Province) sedimentary rocks	volcanic sandstone	Ybs	Undifferentiated, variably foliated, volcaniclastic breccia & sandstone, fine to coarse metatuffs, and greyschist	volcanic sandstone	17_volcanic

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Eastern Province) sedimentary rocks	sandstone	Ybt	undifferentiated volcaniclastic sandstone; flows; pillow lavas; dikes; breccia conglomerate and mudstone	sandstone	15_undifSed
Basement (Eastern Province) sedimentary rocks	volcanic sandstone	Ybt	Undifferentiated bedded marine volcaniclastic sandstone & breccia, and subordinate basaltic, andesitic & dacitic lava flows	volcanic sandstone	17_volcanic
Basement (Eastern Province) sedimentary rocks	breccia	Ybtc	breccia with ankaramitic dikes; tuff; graded limestones	breccia	15_undifSed
Basement (Eastern Province) igneous rocks	basalt	Ybthb	sheet and pillow lava; pillow breccia and sandstone	volcanics	18_crystalline
Basement (Eastern Province) igneous rocks	peridotite	Ybu	Variably sheared and serpentinised peridotite, dunite, pyroxenite & gabbro; altered to greenschist facies; granitoid dikes	ultramafics	18_crystalline
Basement (Eastern Province) sedimentary rocks	siltstone	Ybw	red siltstone with minor sandstone and breccia	volcaniclastics	15_undifSed
Basement (Eastern Province) igneous rocks	gabbro	Ybwhl	concordant sills of gabbroic and dioritic to granophyric composition	gabbro	18_crystalline
Basement (Eastern Province) sedimentary rocks	sandstone	Yc	massive to well bedded grey; red and green sandstone with subordinate mudstone and granule conglomerate	sandstone	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Yc	Sandstone and mudstone with minor volcanic bands and broken formation texture; TZ1	Caples TZ1 sandstone	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Yc	Undifferentiated indurated sandstone-siltstone	Caples Group	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Yc	Sandstone-siltstone with thick green/grey sandstone and grey siltstone; conglomerate; metamorphosed in the east to schist		15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Yc	massive to well bedded grey red and green sandstone with subordinate mudstone and granule conglomerate	sandstone	15_undifSed

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Basement (Eastern Province) metamorphic rocks	metasandstone	Yc2A	TZ IIA weakly foliated grey-green sandstone and minor mudstone with rare volcanics and conglomerate	semischist	18_crystalline
Basement (Eastern Province) metamorphic rocks	metasandstone	Yc2B	TZ IIB well foliated semischist with minor phyllite; greenschist; metachert	semischist	18_crystalline
Basement (Eastern Province) metamorphic rocks	semischist	Yc2a	Weakly foliated sandstone and siltstone-derived semischist	undifferentiated Caples Group	18_crystalline
Basement (Eastern Province) metamorphic rocks	metasandstone	Yc2a	TZ IIA weakly foliated grey-green sandstone and minor mudstone with rare volcanics and conglomerate	semischist	18_crystalline
Basement (Eastern Province) metamorphic rocks	sandstone	Yc2a	Weakly foliated grey-green sandstone and minor mudstone (semischist); minor metaconglomerate; TZ2A	Caples TZ2A semischist	18_crystalline
Basement (Eastern Province) metamorphic rocks	sandstone	Yc2a	Weakly foliated sandstone and siltstone-derived semischist	undiff. Caples Group	18_crystalline
Basement (Eastern Province) metamorphic rocks	sandstone	Yc2a	Tz 2a; weakly to moderately foliated		18_crystalline
Basement (Eastern Province) metamorphic rocks	semischist	Yc2a	Weakly foliated sandstone and siltstone-derived semischist	Caples Group	18_crystalline
Basement (Eastern Province) metamorphic rocks	semischist	Yc2b	Well foliated psammitic and pelitic semischist; phyllite; minor greenschist, metachert and metaconglomerate; TZ2B	Caples TZ2B semischist	18_crystalline
Basement (Eastern Province) metamorphic rocks	semischist	Yc2b	Strongly foliated and transposed sandstone and siltstone-derived semischist	Caples Group	18_crystalline
Basement (Eastern Province) metamorphic rocks	sandstone	Yc2b	Tz 2b; strongly foliated		18_crystalline
Basement (Eastern Province) metamorphic rocks	semischist	Yc2b	Strongly foliated and transposed sandstone and siltstone-derived semischist	undifferentiated Caples Group	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Eastern Province) metamorphic rocks	metasandstone	Yc2b	TZ IIB well foliated semischist with minor phyllite greenschist metachert	semischist	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Yc3	green-grey, laminated, phyllitic albite-qtz-musc-chlorite psammitic and pelitic greyschist, very thin greenschist bands; TZ3	Caples Group undiff TZ3	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Yc3	well foliated TZ III schist with incipient segregation	schist	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Yc3	Well foliated psammitic and pelitic schist with incipient segregration; minor greenschist and metachert; qtz veins common; TZ3	Caples TZ3 schist	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Yc3a	Well segregated quartzofeldspathic schist	Caples Group	18_crystalline
Basement (Eastern Province) metamorphic rocks	sandstone	Yc3a	Tz 3a; strongly foliated; incipient segregation laminae		18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Yc3a	Quartzofeldspathic schist Tz 3a; strongly foliated; incipient segregation laminae	Caples Group	18_crystalline
Basement (Eastern Province) metamorphic rocks	sandstone	Yc3b4	Tz 3b-4; strongly foliated; well developed segregation laminae		18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Yc3b4	Incipiently segregated quartzofeldspathic schist	Caples Group	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Yc3b4	Quartzofeldspathic schist Tz 3b-4; strongly foliated; well developed segregation laminae		18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Yc3b4	Quartzofeldspathic schist Tz 3b-4; strongly foliated; well developed segregation laminae	Caples Group	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Yc3b4	Incipiently segregated quartzofeldspathic schist		18_crystalline

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Basement (Eastern Province) metamorphic rocks	greenschist	Yc3g			18_crystalline
Basement (Eastern Province) sedimentary rocks	sandstone	Yca	Bedded indurated sandstone and siltstone sparse conglomerate horizons	Ward Formation	15_undifSed
Basement (Eastern Province) metamorphic rocks	semischist	Yca2a	Weakly foliated sandstone and siltstone-derived semischist	Caples Group	18_crystalline
Basement (Eastern Province) sedimentary rocks	sandstone	Ycb	Massive to graded sandstone with minor thick conglomerate & mudstone; pillow lava & breccia, chert, thin red&green phyllite;TZ1	Caples TZ1 sandstone	15_undifSed
Basement (Eastern Province) metamorphic rocks	sandstone	Ycb2a	Weakly foliated sandstone (semischist) w minor thick conglomerate & mudstone; pillow lava & breccia; metachert, phyllite; TZ2A	Caples TZ2A semischist	18_crystalline
Basement (Eastern Province) metamorphic rocks	semischist	Ycb2b	Foliated psammitic semischist with minor thick metaconglomerate & pelite; minor greenschist; metachert, red&green phyllite; TZ2B	Caples TZ2B semischist	18_crystalline
Basement (Eastern Province) sedimentary rocks	conglomerate	Ycbc	Polymict granule to boulder conglomerate with sandstone matrix and interbeds; TZ1	Caples TZ1 conglomerate	15_undifSed
Basement (Eastern Province) metamorphic rocks	metaconglomerate	Ycbc	Polymict granule to boulder metaconglomerate with semischistose sandstone matrix and interbeds; TZ2B	Caples TZ2B metaconglomerate	18_crystalline
Basement (Eastern Province) metamorphic rocks	metaconglomerate	Ycc2a	Cobble to boulder metaconglomerate with semischistose sandstone matrix; TZ2A	Caples TZ2A metaconglomerate	18_crystalline
Basement (Eastern Province) sedimentary rocks	mudstone	Ycd	Black mudstone and slate with minor interbeds of red & green sandstone, granule conglomerate, and graded sandstone-mudstone; TZ1	Caples TZ1 mudstone	15_undifSed
Basement (Eastern Province) metamorphic rocks	semischist	Yce2b	Schistose green & grey sandstone(psammitic semischist), black mudstone(pelitic semischist); minor greenschist & metachert; TZ2B	Caples TZ2B semischist	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Yce3	Laminated psammitic and pelitic schist; minor greenschist & metachert; TZ3	Caples TZ3 schist	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Eastern Province) metamorphic rocks	schist	Yce3	Laminated grey psammite; interlayered pale green volcanogenic psammite, pelite & thin greenschists & metacherts; TZ3	Caples TZ3 schist	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Yce3	Grey psammite; interlayered green volcanogenic psammite, pelite & thin greenschists & metacherts; rare serpentinite pods; TZ3	Caples TZ3 schist	18_crystalline
Basement (Eastern Province) metamorphic rocks	marble	Ycf	White to grey fine grained marble with abundant calcite veins	Caples TZ2B marble	18_crystalline
Basement (Eastern Province) sedimentary rocks	metavolcanics	Ycg	Pale to dark green metavolcanics (metabasites and metatuffs); minor metachert and red & green mudstone; TZ1-TZ2A transition	Caples TZ1 metavolcanics	17_volcanic
Basement (Eastern Province) sedimentary rocks	metavolcanics	Ycg	Pale to dark green metavolcanics (metabasites and metatuffs); minor metachert and red & green mudstone; TZ1	Caples TZ1 metavolcanics	17_volcanic
Basement (Eastern Province) metamorphic rocks	greenschist	Ycg2B	pale to dark green variably foliated epidote-chlorite greenschist in all textural grades	schist	18_crystalline
Basement (Eastern Province) metamorphic rocks	greenschist	Ycg3	Foliated and laminated, pale to dark green greenschist; minor metachert and pelitic or psammitic greyschist; TZ3	Caples TZ3 greenschist	18_crystalline
Basement (Eastern Province) sedimentary rocks	sandstone	Ych	In NW; sheared and faulted Caples Group sedimentary rocks with intercalated mafic and ultramafic rocks	Haukawakawa Sequence	15_undifSed
Basement (Eastern Province) sedimentary rocks	mudstone	Yci	black and red mudstone with minor sandstone interbeds	mudstone	15_undifSed
Basement (Eastern Province) metamorphic rocks	pelite	Yci3	Laminated pelitic schist with minor greenschist, metachert, and psammitic schist bands; TZ3	Caples TZ3 pelite schist	18_crystalline
Basement (Eastern Province) sedimentary rocks	sandstone	Yck	Red and green volcaniclastic sandstone and mudstone with intraformational mud chip breccia; TZ1	Caples TZ1 sandstone	15_undifSed
Basement (Eastern Province) metamorphic rocks	sandstone	Yck2a	Weakly foliated green volcaniclastic sandstone (semischist) w minor zst & mud chip breccia; minor greenschist & chert bands;TZ2A	Caples TZ2A semischist	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Eastern Province) metamorphic rocks	semischist	Yck2b	Well foliated green sandstone (psammitic semischist) with minor siltstone and yellow-green mud chip breccia; TZ2B	Caples TZ2B semischist	18_crystalline
Basement (Eastern Province) sedimentary rocks	sandstone	Yckcy	distinctive red and green sandstone and mudstone	sandstone	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Ycm	Massive/dm- m-bedded, grey to green, relatively quartzose sandstone with minor thin mudstone interbeds & rare conglomerate; TZ1	Caples TZ1 sandstone	15_undifSed
Basement (Eastern Province) metamorphic rocks	sandstone	Ycm2a	Weakly foliated, grey to green, sometimes brown, sandstone (semischist) with minor mudstone; TZ2A	Caples TZ2A semischist	18_crystalline
Basement (Eastern Province) metamorphic rocks	semischist	Ycm2b	Foliated, grey to green, sandstone (psammitic semischist) with minor mudstone (pelitic semischist); TZ2B	Caples TZ2B semischist	18_crystalline
Basement (Eastern Province) sedimentary rocks	sandstone	Ycn	Massive to m-bedded grey sandstone; red and green massive sandstone with minor mudstone; rare chert; TZ1	Caples TZ1 sandstone	15_undifSed
Basement (Eastern Province) metamorphic rocks	sandstone	Ycn2a	Weakly foliated grey to green sandstone (semischist) with minor mudstone; TZ2A	Caples TZ2A semischist	18_crystalline
Basement (Eastern Province) metamorphic rocks	semischist	Ycn2b	Well foliated sandstone (psammitic semischist) with minor phyllite; TZ2B	Caples TZ2B semischist	18_crystalline
Basement (Eastern Province) sedimentary rocks	sandstone	Yco	Strongly indurated sandstone and argillite; metamorphism up to pumpellyite-actinolite facies.		15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Yco	Strongly indurated sandstone and argillite. Metamorphism up to pumpellyite-actinolite facies.		15_undifSed
Basement (Eastern Province) igneous rocks	basalt	Ycp	Massive basalt, pillow lava, metatuff, chert and argillite with prehnite-pumpellyite facies metamorphism.		18_crystalline
Basement (Eastern Province) sedimentary rocks	chert	Ycpc	Beds dominated by chert and siliceous argillite.	chert	15_undifSed

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Basement (Eastern Province) melange	melange	Ycpm	Melange and broken formation	melange	15_undifSed
Basement (Eastern Province) igneous rocks	basalt	Ycpv	Beds dominated by basaltic lava flows and pillow lavas.	basalt	18_crystalline
Basement (Eastern Province) sedimentary rocks	quartzite	Ycq2a	Layered; dominantly red chert and quartzite; interbedded with grey siltstone and mudstone; minor basalt and gabbro		15_undifSed
Basement (Eastern Province) metamorphic rocks	quartzite	Ycq2b	Quartzite minor chert igneous rocks sandstone siltstone phyllonite	Wakamarina Quartzite	18_crystalline
Basement (Eastern Province) metamorphic rocks	metavolcanics	Ycr2a	Weakly foliated andesitic to basaltic flows, pillow lavas, & hyaloclastic breccia; minor volcaniclastic sst & metachert; TZ2A	Caples TZ2A metavolcanics	18_crystalline
Basement (Eastern Province) metamorphic rocks	greenschist	Ycr2b	Greenschist (foliated andesitic-basaltic flows, pillow lavas,& hyaloclastic breccia); minor volcaniclastic sst & metachert; TZ2B	Caples TZ2B greenschist	18_crystalline
Basement (Eastern Province) metamorphic rocks	greenschist	Ycr3	Foliated&laminated metavolcanic greenschist(from basalt, pillow lavas, hyaloclastites & volc sst); minor metachert & pelite; TZ3	Caples TZ3 greenschist	18_crystalline
Basement (Eastern Province) sedimentary rocks	sandstone	Ycs	Sandstone with thin interbedded siltstone	Star Formation	15_undifSed
Basement (Eastern Province) metamorphic rocks	semischist	Ycs2a	Weakly foliated sandstone and siltstone-derived semischist	Star Formation	18_crystalline
Basement (Eastern Province) metamorphic rocks	semischist	Ycs2b	Strongly foliated and transposed sandstone and siltstone-derived semischist	Star Formation	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Ycs3a	Well segregated quartzofeldspathic schist	Star Formation	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Ycs3b4	Incipiently segregated quartzofeldspathic schist	Star Formation	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Eastern Province) sedimentary rocks	sandstone	Ycu	dm- to m-bedded sandstone with abundant sedimentary structures; black mudstone; minor conglomerate and rare chert; TZ1	Caples TZ1 sandstone	15_undifSed
Basement (Eastern Province) metamorphic rocks	sandstone	Ycu2a	Weakly foliated sandstone (semischist) and minor mudstone (pelite); TZ2A	Caples TZ2A semischist	18_crystalline
Basement (Eastern Province) sedimentary rocks	sandstone	Ycw	Bedded green sandstone and red siltstone		15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Ycw	Bedded indurated sandstone-siltstone	Wether Formation	15_undifSed
Basement (Eastern Province) metamorphic rocks	sandstone	Ycw2a	Weakly foliated sandstone and siltstone-derived semischist	Wether Formation	18_crystalline
Basement (Eastern Province) metamorphic rocks	semischist	Ycz2b	Psammitic and pelitic semischist with minor metavolcanics, red & green phyllite; metaconglomerate, and metachert; TZ2B	Caples TZ2B semischist	18_crystalline
Basement (Eastern Province) metamorphic rocks	semischist	Ycz3	Psammitic and pelitic schist with minor metavolcanics (greenschist), red & green phyllite; metaconglomerate and metachert; TZ3	Caples TZ3 schist	18_crystalline
Basement (Eastern Province) igneous rocks	peridotite	Yd	Peridotite, mainly harzburgite; weakly serpentinised; raised crystals of orthopyroxene form on red-brown weathered surfaces	Dun Mountain Ultramafics Group	18_crystalline
Basement (Eastern Province) igneous rocks	harzburgite	Yd	Serpentinised harzburgite; minor dunite and pyroxenite; sparse rodingite dikes		18_crystalline
Basement (Eastern Province) metamorphic rocks	harzburgite	Yd	Sheared, serpentinised harzburgite with xenoliths of metasomatised gabbro.	Wairere serpentinite	18_crystalline
Basement (Eastern Province) igneous rocks	gabbro	Yda	gabbro; norite; mafic diorite; minor basic pegmatite; variably brecciated	gabbro	18_crystalline
Basement (Eastern Province) igneous rocks	harzburgite	Ydc	Harzburgite dunite pyroxenite with gabbro rodingite dikes and Cu/Cr mineralisation variably serpentinised.	Dun Mountain Ultramafics Group	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Eastern Province) igneous rocks	harzburgite	Ydm	Harzburgite and minor dunite variably serpentinised.	Dun Mountain Ultramafics Group	18_crystalline
Basement (Eastern Province) igneous rocks	harzburgite	Ydp	Proto- clastic harzburgite variably serpentinised.	Dun Mountain Ultramafics Group	18_crystalline
Basement (Eastern Province) igneous rocks	peridotite	Ydp	Interlayered, partly serpentinised dunite, wehrlite, clinopyroxenite, troctolite, anorthositic gabbro, eucrite, cpx-hbl gabbro	ultramafics	18_crystalline
Basement (Eastern Province) igneous rocks	peridotite	Ydp	Massive, locally layered, partly serpentinised harzburgite & minor dunite; orthopyroxene pegmatite, dolerite & rodingite dikes	ultramafics	18_crystalline
Basement (Eastern Province) melange	serpentinite	Ydpm	Peridotite and some gabbro in a sheared serpentinite matrix	melange	18_crystalline
Basement (Eastern Province) metamorphic rocks	serpentinite	Yds	Sheared to massive serpentinite from parent harzburgite & minor dunite; rodingitised pyroxenite & dolerite dikes; asbestos veins	ultramafics	18_crystalline
Basement (Eastern Province) metamorphic rocks	serpentinite	Yds	Serpentinised shear zones of peridotite	Dun Mountain Ultramafics Group	18_crystalline
Basement (Eastern Province) metamorphic rocks	serpentinite	Yds	Serpentinite shear zones derived from periodite, mylonitised rodingite dikes	Dun Mountain Ultramafics Group	18_crystalline
Basement (Eastern Province) melange	serpentinite	Ydsm	Melange of sheared & serpentinised peridotite (mainly harzburgite & dunite) & gabbro with rodingite dikes & rare asbestos veins	melange	18_crystalline
Basement (Eastern Province) melange	serpentinite	Ydu	Melange of peridotite, gabbro, & minor dolerite tectonic inclusions in a sheared serpentinite matrix; rodingite dikes	melange	18_crystalline
Basement (Eastern Province) melange	gabbro	Ydug	Melange of mainly altered hornblende gabbro with a minor serpentinite matrix; basalt dike	melange	18_crystalline
Basement (Eastern Province) sedimentary rocks	breccia	Ygg	volcaniclastic breccia; dolerite; basalt; tuff; sandstone; and impure marble; variably hornfelsed and foliated	breccia	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Eastern Province) melange	serpentinite	Ygm	Melange consisting of blocks of gabbro, dolerite, greenschist, and sandstone in a sheared mudstone or serpentinite matrix	melange	18_crystalline
Basement (Eastern Province) melange	melange	Yk	Quartz-rich flysch and conglomerate, and volcanic-limestone-mudstone melange; textural zone IIA		15_undifSed
Basement (Eastern Province) igneous rocks	basalt	Yl	Undifferentiated basalt and gabbro	undiff. Livingston Volcanics Gro	18_crystalline
Basement (Eastern Province) igneous rocks	spilite	Yl	brecciated volcanics with minor dolerite gabbro and hyaloclastite; minor tuff and hornfels	spilite	18_crystalline
Basement (Eastern Province) igneous rocks	spilite	Yl	Undifferentiated spilitised basaltic volcanics & pillow lava, gabbro, dolerite, and sheeted dike complex; volcaniclastics	volcanics	18_crystalline
Basement (Eastern Province) igneous rocks	gabbro	Yla	Massive to layered coarse grained hornblende gabbro	gabbro	18_crystalline
Basement (Eastern Province) igneous rocks	dolerite	Yld	Mafic (dolerite) to intermediate dike complex hosted by minor gabbro	volcanics	18_crystalline
Basement (Eastern Province) igneous rocks	volcanic breccia	Yle	Altered hyaloclastite and volcanic breccia; mafic dikes	volcanics	17_volcanic
Basement (Eastern Province) igneous rocks	basalt	Ylg	Fine grained basalt	Glennie Formation	18_crystalline
Basement (Eastern Province) igneous rocks	keratophyre	Ylo	weathered and shattered altered volcanics and granite	volcanics	18_crystalline
Basement (Eastern Province) igneous rocks	diorite	Ylp	diorite; tonalite; trondhjemite; microdiorite; variably brecciated	diorite	18_crystalline
Basement (Eastern Province) melange	keratophyre	Ylq	melange of quartz keratophyre with minor plagiogranite and sediment	keratophyre	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Eastern Province) sedimentary rocks	sandstone	Yls	Sheared quartzofeldspathic sandstone and siltstone inclusion in melange belt	sandstone	15_undifSed
Basement (Eastern Province) sedimentary rocks	mudstone	Ylsw	Poorly bedded black mudstone (argillite), rare sandstone beds and some red siltstone bands (2m thick)	mudstone	15_undifSed
Basement (Eastern Province) igneous rocks	gabbro	Ylt	Massive; medium-grained gabbro with basal gabbro dike complex; undifferentiated slivers of basalt	Tinline Formation	18_crystalline
Basement (Eastern Province) igneous rocks	gabbro	Ylt	Massive; medium-grained gabbro with basal gabbro dike complex; undifferentiated slivers of basalt		18_crystalline
Basement (Eastern Province) igneous rocks	gabbro	Ylt	Coarse-grained gabbro sheeted dikes and massive microgabbro at top	Tinline Formation	18_crystalline
Basement (Eastern Province) igneous rocks	spilite	Ylv	spilitised basaltic flows and pillow lavas; mafic dikes	volcanics	18_crystalline
Basement (Eastern Province) melange	spilite	Ylw	Melange of spilitic flows and pillow lavas with tectonic inclusions of gabbro, dolerite, greenschist, sediments, and marble	melange	18_crystalline
Basement (Eastern Province) sedimentary rocks	sandstone	Ymt	Well bedded relatively quartzofeldspathic sandstone & siltstone; minor impure limestone with interbedded dark grey mudstone	Maitai sandstone	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Ymt	Well bedded sandstone-siltstone widespread and locally abundant atomodesmatinid fossils	Tramway Sandstone	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Ymt	Well bedded sandstone and siltstone; impure limestone lenses and layers of atomodesmatinid fossils; poorly bedded siltstone	Tramway Sandstone	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Ymt	grey well bedded sandstone and siltstone	sandstone	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Ymt	Well bedded sandstone and siltstone; impure limestone lenses and layers of atomodesmatinid fossils; poorly bedded siltstone		15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Eastern Province) sedimentary rocks	volcanic breccia	Ymu	Coarse red & green volcaniclastic breccia with hematised sandy matrix; lenses of sandstone & siltstone; very rare limestone	Maitai volcanic breccia	17_volcanic
Basement (Eastern Province) sedimentary rocks	sandstone	Ymu	Purplish-red breccia grey sandstone and dark grey mudstone	Upukerora Formation	15_undifSed
Basement (Eastern Province) sedimentary rocks	breccia	Ymu	Breccia and poorly sorted conglomerate		15_undifSed
Basement (Eastern Province) sedimentary rocks	limestone	Ymw	Bedded, fine-grained, bioclastic limestone formed from Atomodesmatinid shell debris; minor sandstone	Maitai limestone	15_undifSed
Basement (Eastern Province) sedimentary rocks	limestone	Ymw	Well bedded limestone and calcareous siltstone	Wooded Peak Limestone	15_undifSed
Basement (Eastern Province) sedimentary rocks	limestone	Ymw	Well bedded limestone, and calcareous sandstone and siltstone		15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Ymw	Bedded limestone and calcareous sandstone	Wooded Peak Limestone	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Ymws	Calcareous & volcaniclastic green sandstone and siltstone interbedded with sandy limestone	Maitai sandstone	15_undifSed
Basement (Western Province) sedimentary rocks	sandstone	Ypf	Highly silicified sandstone-siltstone with beds of mudstone and conglomerate	Pepin Group	15_undifSed
Basement (Eastern Province) sedimentary rocks	limestone	Ypg	limestone with subordinate conglomerate sandstone and mudstone	limestone	15_undifSed
Basement (Western Province) sedimentary rocks	sandstone	Ypp	Quartzite pelitic schist graphitic slate pebbly sandstone and metaconglomerate	Cover	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Yt	Massive to bedded, fine to coarse, well indurated greywacke sandstone, with subordinate argillitic mudstone; TZ1	Torlesse TZ1 greywacke	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Eastern Province) sedimentary rocks	greywacke	Yt1	quartzofeldspathic sandstone (greywacke) interbedded with mudstone (argillite)		15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Yt1	Well indurated; greywacke sandstone; argillitic mudstone/siltstone; minor conglomerate/tuffaceous sandstone/volcanics; TZ1	Torlesse TZ1 greywacke	15_undifSed
Basement (Eastern Province) sedimentary rocks	conglomerate	Yt1_c	Layers/lenses of granule to pebble conglomerate; clasts may include subrounded granitoid/vein quartz/greywacke sandstone	Torlesse TZ1 conglomerate	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Yt1_m	Thin-bedded sandstone/siltstone flysch; minor black mudstone+red argillite+conglomerate+tuffaceous sandstone; TZ1	Torlesse TZ1 thin-bedded sst/zst	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	Yt1_n	Hard; massive greywacke sandstone with concretions+conglomerate+mudstone clasts; minor thin-bedded sandstone/siltstone; TZ1	Torlesse TZ1 massive sandst	15_undifSed
Basement (Eastern Province) sedimentary rocks	siltstone	Yt1_s	Thin-bedded siltstone with minor sandstone channels; parallel & ripple lamination; commonly disrupted/folded; TZ1	Torlesse TZ1 thin-bedded siltst	15_undifSed
Basement (Eastern Province) metamorphic rocks	sandstone	Yt2a	Slightly foliated; schistose greywacke sandstone and argillitic mudstone; low-grade metatuff and metachert; TZ2A	Torlesse TZ2A semischist	18_crystalline
Basement (Eastern Province) metamorphic rocks	sandstone	Yt2a	Weakly foliated greywacke sandstone & subordinate argillitic-slaty mudstone (collectively called semischist); rare congl.; TZ2A	Torlesse TZ2A semischist	18_crystalline
Basement (Eastern Province) metamorphic rocks	sandstone	Yt2a	Weakly foliated or cleaved greywacke & argillitc mst (semischist); minor conglomerate,metachert,mafic metavolcanics,red mst;TZ2A	Torlesse TZ2A semischist	18_crystalline
Basement (Eastern Province) metamorphic rocks	greywacke	Yt2a	weakly foliated quartzofeldspathic sandstone (greywacke) interbedded with mudstone (argillite)		18_crystalline
Basement (Eastern Province) metamorphic rocks	cataclasite	Yt2a_x	Variably crushed/brecciated cleaved TZ2A greywacke sandstone & argillitic mudstone; clayey pug zones	Torlesse TZ2A crush zone	18_crystalline
Basement (Eastern Province) metamorphic rocks	breccia	Yt2acz	Late Cenozoic crush zone of shattered and crushed TZ2A greywacke sandstone and argillitic mudstone	Torlesse fault breccia	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Eastern Province) metamorphic rocks	semischist	Yt2b	Planar-foliated; low-grade psammitic/pelitic semischist; minor low-grade metatuff and metachert; rare metaconglomerate TZ2B	Torlesse TZ2B semischist	18_crystalline
Basement (Eastern Province) metamorphic rocks	semischist	Yt2b	Planar-foliated; low-grade psammitic/pelitic semischist; minor low-grade metatuff and metachert; TZ2B	Torlesse TZ2B semischist	18_crystalline
Basement (Eastern Province) metamorphic rocks	semischist	Yt2b	Well foliated psammitic & subordinate pelitic semischist; rare metaconglomerate; TZ2B	Torlesse TZ2B semischist	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Yt2b	well foliated quartzofeldspathic sandstone (greywacke) interbedded with mudstone (argillite) .		18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Yt3	Prominently planar-foliated; psammitic and pelitic schist; rare greenschist, metachert; strained metaconglomerate & marble TZ3	Torlesse TZ3 schist	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Yt3	Well foliated, incipiently segregated psammitic & subordinate pelitic schist; minor greenschist & conglomerate; rare marble; TZ3	Torlesse TZ3 schist	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Yt3	Schistose quartzofeldspathic sandstone (greywacke) interbedded with mudstone (argillite)		18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Yt3	Prominently planar-foliated; psammitic and pelitic schist; rare greenschist, metachert, and strained conglomerate; TZ3	Torlesse TZ3 schist	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Yt4	Strongly foliated and segregated/quartz-laminated psammitic and pelitic schist; minor greenschist; rare metachert; TZ4	Torlesse TZ4 schist	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Yt4	Schistose quartzofeldspathic sandstone (greywacke) interbedded with mudstone (argillite)		18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Yt4	Well segregated psammitic-rich greyschist, subordinate pelitic schist; rare greenschist/amphibolite and metachert; TZ4	Torlesse TZ4 schist	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Yt4	TZ IV pelitic schist with subordinate psammitic schist	schist	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Eastern Province) metamorphic rocks	schist	Yt4	Prominently quartz-albite segregated psammitic and pelitic greyschist; rare greenschist/amphibolite and metachert; TZ4	Torlesse TZ4 schist	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Yt4	Prominently quartz-albite segregated psammitic and pelitic greyschist; rare greenschist and metachert; TZ4	Torlesse TZ4 schist	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Yt4	Well segregated psammitic-rich greyschist, subordinate pelitic schist; rare amphibolite and metachert; TZ4	Torlesse TZ4 schist	18_crystalline
Basement (Eastern Province) metamorphic rocks	greenschist	Yt4g	TZ IIIB-IV epidote-chlorite-albite-quartz-stilpnomelane greenschist	greenschist	18_crystalline
Basement (Eastern Province) metamorphic rocks	marble	Ytb2a	Weakly foliated blue-grey crystalline marble with rare conodonts; red, green and black chert and mudstone; metatuff; textural z		18_crystalline
Basement (Eastern Province) sedimentary rocks	breccia	Ytbf	knockers of manganiferous chert; sandstone and igneous rocks in a matrix of sheared red and grey argillite; along strike from Ki		15_undifSed
Basement (Eastern Province) sedimentary rocks	metaconglomerate	Ytc	pebble and cobble conglomerate mostly dominated by quartz clasts; some also contain metasediment volcanic and granitoid clasts		15_undifSed
Basement (Eastern Province) sedimentary rocks	breccia	Ytcz	breccia and cataclasite from brittle deformation of greywacke and argillite along faults		15_undifSed
Basement (Eastern Province) metamorphic rocks	breccia	Ytcz2b	breccia and cataclasite from brittle deformation of greywacke and argillite along faults		18_crystalline
Basement (Eastern Province) metamorphic rocks	greenschist	Ytg2b	Epidote- and chlorite-rich metavolcanics (greenschist) with rare manganiferous metachert bands; TZ2B	Torlesse TZ2B greenschist	18_crystalline
Basement (Eastern Province) metamorphic rocks	greenschist	Ytg4	Abundant (>10%) greenschist/amphibolite bands in psammitic and pelitic greyschist; minor metachert; TZ4	Torlesse TZ4 greenschist	18_crystalline
Basement (Eastern Province) metamorphic rocks	amphibolite	Ytg4	Abundant (>10%) amphibolite bands in psammitic and pelitic greyschist; minor metachert; TZ4	Torlesse TZ4 amphibolite	18_crystalline

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Basement (Eastern Province) sedimentary rocks	metapelite	Yti	maroon and green phyllite and other coloured argillite marker units at Dansey Pass and elsewhere; black mudstone-dominated unit		15_undifSed
Basement (Eastern Province) metamorphic rocks	mudstone	Yti2a	Argillitic mudstone with slaty cleavage (pelitic semischist); minor greywacke sandstone; TZ2A	Torlesse TZ2A pelitic semischist	18_crystalline
Basement (Eastern Province) metamorphic rocks	semischist	Yti2b	Well foliated pelitic semischist (slate) with subordinate psammitic semischist and quartz veins; TZ2B	Torlesse TZ2B pelitic semischist	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Yti3	Foliated and laminated pelitic schist with minor psammitic schist and greenschist; TZ3	Torlesse TZ3 pelitic semischist	18_crystalline
Basement (Eastern Province) metamorphic rocks	greywacke	Ytk2a	Greenish quartzofeldspathic schist; lamination consisting of quartz/albite and muscovite/chlorite/epidote layers; slightly foli		18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Ytk2b	Greenish quartzofeldspathic schist; lamination consisting of quartz/albite and muscovite/chlorite/epidote layers; moderately fo		18_crystalline
Basement (Eastern Province) igneous rocks	basalt	Ytv	Basalt		18_crystalline
Basement (Eastern Province) igneous rocks	metavolcanics	Ytv	lava tuff and intrusive volcanic rocks intercalated with greywacke and argillite; associated limestone/marble; red/green argill		18_crystalline
Basement (Eastern Province) metamorphic rocks	metavolcanics	Ytv2a	lava tuff and intrusive volcanic rocks intercalated with greywacke and argillite; associated limestone/marble; red/green argill		18_crystalline
Basement (Eastern Province) metamorphic rocks	metavolcanics	Ytv2b	Epidote- and chlorite-rich mafic metavolcanics (greenschist) with metachert bands; minor psammitic-pelitic semischist; TZ2B	Torlesse TZ2B metavolcanics	18_crystalline
Basement (Eastern Province) sedimentary rocks	sandstone	Yu	volcaniclastic sandstone; siltstone limestone and rare conglomerate and tuff	sandstone	15_undifSed
Basement (Eastern Province) metamorphic rocks	semischist	Yw2b	Planar-foliated; low-grade psammitic/pelitic semischist; minor low-grade metatuff and metachert; TZ2B	Torlesse Wanaka TZ2B semischist	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Eastern Province) metamorphic rocks	psammite	Yw3	Prominently planar-foliated psammitic and subordinate pelitic schist; minor greenschist and metachert; TZ3	Torlesse Wanaka TZ3 schist	18_crystalline
Basement (Eastern Province) metamorphic rocks	psammite	Yw4	Well segregated psammitic-rich greyschist, subordinate pelitic schist; minor greenschist, metachert, marble; TZ4	Torlesse Wanaka TZ4 schist	18_crystalline
Basement (Eastern Province) metamorphic rocks	psammite	Yw4	Well segregated psammitic-rich greyschist, subordinate pelitic schist; minor greenschist and metachert; TZ4	Torlesse Wanaka TZ4 schist	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	Yw4	Undifferentiated well foliated and segregated psammitic and pelitic schist with greenschist and metachert bands; TZ4	Torlesse Wanaka TZ4 schist	18_crystalline
Basement (Eastern Province) metamorphic rocks	greenschist	Ywg4	Epidote- and chlorite-rich greenschist with subordinate pelitic schist and minor metachert bands; TZ4	Torlesse Wanaka TZ4 greenschist	18_crystalline
Basement (Eastern Province) metamorphic rocks	greenschist	Ywg4	Abundant (>10%) greenschist bands in psammitic and pelitic greyschist, minor metachert; TZ4	Torlesse Wanaka TZ4 greenschist	18_crystalline
Basement (Eastern Province) metamorphic rocks	pelite	Ywi4	Segregated pelitic schist with subordinate psammitic schist; minor greenschist and metachert; TZ4	Wanaka TZ4 pelitic schist	18_crystalline
Basement (Eastern Province) metamorphic rocks	psammite	Ywn4	Segregated psammitic schist with subordinate pelitic schist; rare greenschist and metachert; TZ4	Wanaka TZ4 psammitic schist	18_crystalline
Basement (Eastern Province) metamorphic rocks	metachert	Ywt4	Laminated to massive piemontite metachert; may have some minor greenschist; TZ4	Torlesse Wanaka TZ4 metachert	18_crystalline
Basement (Eastern Province) metamorphic rocks	serpentinite	Ywx4	Serpentinite, with talc schist and greenschist, derived from an ultramafic body	Torlesse Wanaka TZ4 ultramafics	18_crystalline
Basement (Median Batholith) igneous rocks	anorthosite	eCabga	Variably foliated&metamorphosed layered intrusion of anorthosite, gabbroic anorthosite & amphibolite;minor troctolite&peridotite	anorthosite	18_crystalline
Basement (Median Batholith) igneous rocks	granite	eCaep	Massive to weakly foliated, equigranular, biotite±muscovite±rare garnet granite, granodiorite and tonalite	granite	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Median Batholith) igneous rocks	diorite	eCaepd	Raft of variably foliated diorite, quartz diorite and minor hornblende gabbro in Mt Evans Pluton	diorite	18_crystalline
Basement (Median Batholith) igneous rocks	granite	eCag	Medium to coarse grained, weakly to strongly foliated biotite granite and granodiorite unconformably beneath Loch Burn Formation	granite	18_crystalline
Basement (Median Batholith) igneous rocks	tonalite	eCaho	Medium grained, gneissic, bio±ms±gt tonalite, granodiorite & granite; K feldspar porphyroclasts in places	tonalite	18_crystalline
Basement (Median Batholith) igneous rocks	tonalite	eCahp	Med-coarse gr, massive-weakly foliated, equigranular, bio-hbl±gt tonalite & qtz diorite, minor granodiorite; calc-silicate rafts	tonalite	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	eCakt	Medium grained, weakly foliated to strongly gneissic, equigranular bio±ms±gt granodiorite, tonalite and granite	granodiorite	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	eCanetp	coarse biotite granodiorite and tonalite in fault bounded slivers	granodiorite	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	eCanrg	Coarse-grained, generally massive, biotite granodiorite & granite with conspicous K-feldspar megacrysts. Foliation near faults	granodiorite	18_crystalline
Basement (Median Batholith) igneous rocks	granite	eCapo	Light pink to white, medium-coarse grained, massive, bio-hbl granite with minor granodiorite; locally K-feldspar megacrystic	granite	18_crystalline
Basement (Median Batholith) metamorphic rocks	orthogneiss	eCarimo	Variably foliated biotite granodiorite orthogneiss, in places with K-feldspar megacrysts	orthogneiss	18_crystalline
Basement (Median Batholith) igneous rocks	granite	eCarugp	coarse massive homogenous biotite granite and leucogranite	granite pluton	18_crystalline
Basement (Median Batholith) metamorphic rocks	orthogneiss	eCataho	strongly foliated fine biotite ± titanite ± muscovite granite and leucogranite orthogneiss	orthogneiss	18_crystalline
Basement (Median Batholith) igneous rocks	diorite	eCati	Medium to very coarse gr, massive to gneissic diorite, gabbro, quartz diorite & minor tonalite; locally altered; rare pyroxenite	diorite	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Median Batholith) igneous rocks	quartz diorite	eCatqd	Medium grained, weakly foliated, hornblende-biotite±clinopyroxene quartz diorite, commonly amphibolitised; minor tonalite	diorite	18_crystalline
Basement (Median Batholith) igneous rocks	quartz diorite	eCawd	Fine-medium grained, massive to weakly foliated, hbl-bio quartz diorite and diorite; minor fine grained tonalite	diorite	18_crystalline
Basement (Eastern Province) sedimentary rocks	sandstone	eJd	fine sandstone and siltstone with rare conglomerate tuff and grit beds	sandstone	15_undifSed
Basement (Eastern Province) sedimentary rocks	siltstone	eJdm	fine sandstone and siltstone with rare conglomerate and grit beds	siltstone	15_undifSed
Basement (Median Batholith) igneous rocks	granodiorite	eJeucp	fine to medium massive biotite titanite granodiorite and granite	granodiorite pluton	18_crystalline
Basement (Eastern Province) metamorphic rocks	schist	eJpg	Volcaniclastic sediments, conglomerate rhyolite and dacite, variably foliated and mylonitised metamorphosed to greenschist and a	metasediments	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	eK59	Fine gr, massive, equigranular granodiorite, granite & leucogranite w isolated distinctly euhedral biotite; minor leucotonalite	granodiorite	18_crystalline
Basement (Median Batholith) igneous rocks	porphyry	eKJpy	Feldspar porphyry: plagioclase & rare biotite phenocrysts in a fine altered matrix of plag-hbl-bio(microdiorite); cut by granite	porphyry	18_crystalline
Basement (Median Batholith) metamorphic rocks	orthogneiss	eKbg	Coarse interlayered omphacite granulite & omphacite-gt eclogite derived from diorite & gabbro-norite protoliths (orthogneiss)	orthogneiss	18_crystalline
Basement (Median Batholith) igneous rocks	granite	eKblaip	massive to foliated medium biotite muscovite garnet granite	granite pluton	18_crystalline
Basement (Median Batholith) igneous rocks	diorite	eKbpp	Fine to medium gr, massive, heterogeneous, acicular-hornblende diorite, qtz diorite & biotite-rich tonalite; minor granodiorite	diorite	18_crystalline
Basement (Median Batholith) igneous rocks	granite	eKbrp	Medium to coarse grained, massive to weakly foliated, commonly K-feldspar megacrystic, biotite granite and granodiorite	granite	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Median Batholith) mylonite	mylonite	eKbrpm	Mylonitised biotite granite and granodiorite with K-feldspar porphyroclasts; pervasive mylonite fabric	mylonite	18_crystalline
Basement (Median Batholith) igneous rocks	cataclasite	eKbrpz	Cataclastic to mylonitic rock derived from granite and subordinate metasediment, gabbro and diorite	cataclasite	18_crystalline
Basement (Median Batholith) metamorphic rocks	gneiss	eKbunas	foliated diorite; granodiorite and microdiorite of Bungaree Suite	gneiss	18_crystalline
Basement (Median Batholith) igneous rocks	diorite	eKbunas	heterogeneous diorite; granodiorite; granite; microdiorite; andesite and basalt	diorite	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	eKcap	massive fine biotite quartz monzodiorite; granodiorite; granite and leucogranite with pegmatite and alplite dikes	granite pluton	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	eKcar	Medium to coarse grained, massive, equigranular, biotite±hornblende granodiorite and granite; minor tonalite	granodiorite	18_crystalline
Basement (Median Batholith) igneous rocks	monzodiorite	eKdoup	massive medium hornblene biotite titanite quartz monzodiorite and granodiorite	monzodiorite pluton	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	eKeascmp	Fine to medium biotite hornblende granodiorite and quartz monzodiorite with gabbro and diorite rafts	granodiorite pluton	18_crystalline
Basement (Median Batholith) igneous rocks	granite	eKeasp	granite and quartz monzodiorite with accessory biotite muscovite and rare hornblende; with diotie and metasedimentary xenoliths	granite	18_crystalline
Basement (Median Batholith) igneous rocks	diorite	eKescr	rafts of gabbro and diorite within Escarpment Pluton		18_crystalline
Basement (Median Batholith) igneous rocks	tonalite	eKffp	Medium gr, variably foliated, equigranular bio±hbl tonalite; subordinate diorite, qtz diorite & granodiorite; rare metased rafts	tonalite	18_crystalline
Basement (Median Batholith) igneous rocks	tonalite	eKffpf	Variably foliated tonalite, quartz diorite & granodiorite interlayered with psammitic & amphibolitic schists at 1-100m scale	tonalite	18_crystalline

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Basement (Median Batholith) igneous rocks	granite	eKfo	Medium-coarse gr, well-foliated biotite granite & granodiorite with pink K-feldspar megacrysts; diorite & qtz diorite xenoliths	granite	18_crystalline
Basement (Median Batholith) igneous rocks	granite	eKfp	Fine to medium gr, massive, equigranular biotite±muscovite granite & subordinate granodiorite; minor pegmatite & leucogranite	granite	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	eKfrenp	massive fine biotite ± hornblende ± muscovite granodiorite and granite	granodiorite pluton	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	eKg	fine to coarse grained biotite granodiorite to tonalite; gabbro and diorite on Blackmount Fault	granite	18_crystalline
Basement (Western Province) igneous rocks	monzodiorite	eKg	2-pyroxene monzodiorite-granodiorite-granite; includes pegmatite & carbonate + mafic dykes and hnbl-diop gabbro plugs	Early Cretaceous granite	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	eKg	Fine to coarse grained biotite granodiorite and biotite-hornblende tonalite	granodiorite	18_crystalline
Basement (Median Batholith) igneous rocks	granite	eKgogp	massive fine grained biotite granite and granodiorite with leucogranite pegmatite and aplite dikes	granite	18_crystalline
Basement (Median Batholith) mylonite	mylonite	eKgsz	Zone of strongly foliated to mylonitic rocks derived from adjacent (eastern side of zone) granitic and dioritic rocks	mylonite	18_crystalline
Basement (Median Batholith) igneous rocks	hornblendite	eKh	Massive hornblendite and hornblende peridotite with minor dunite and pyroxenite	ultramafic	18_crystalline
Basement (Median Batholith) igneous rocks	hornblendite	eKh	Massive hornblendite with minor pyroxenite and peridotite	ultramafic	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	eKhvg	Fine to coarse grained, massive to weakly foliated, equigranular, heterogeneous biotite granodiorite, tonalite and granite	granodiorite	18_crystalline
Basement (Median Batholith) igneous rocks	granite	eKiig	Variably foliated, commonly K-feldspar megacrystic, biotite±muscovite±garnet granite and subordinate granodiorite	granite	18_crystalline

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Basement (Median Batholith) igneous rocks	granite	eKkanp	massive fine grained biotite granite and granodiorite with leucogranite pegmatite and aplite dikes	granite	18_crystalline
Basement (Median Batholith) igneous rocks	quartz monzonite	eKlJeg	Medium, strongly lineated, variably foliated to gneissic aegirine-arfvedsonite-biotite qtz monzonite, qtz syenite & syenogranite	granite	18_crystalline
Basement (Median Batholith) igneous rocks	granite	eKlorp	massive fine biotite ± titanite granodiorite; granite and quartz monzodiorite with aplite and pegmatite dikes	granite pluton	18_crystalline
Early Cretaceous sedimentary rocks	mudstone	eKma	moderately indurated mudstone, minor sandstone/mudstone (eKka), sandstone, coloured mudstone, tuffaceous bed		15_undifSed
Early Cretaceous sedimentary rocks	mudstone	eKma	Moderately indurated mudstone, minor sandstone/mudstone (eKka), sandstone, coloured mudstone, tuffaceous bed		15_undifSed
Early Cretaceous sedimentary rocks	sandstone	eKmaa	Sandstone/mudstone, minor conglomerate.		15_undifSed
Basement (Median Batholith) igneous rocks	granodiorite	eKmabp	heterogeneous fine to medium biotite titanite quartz monzodiorite; granodiorite and granite with mafic inclusions	monzodiorite pluton	18_crystalline
Basement (Median Batholith) metamorphic rocks	amphibolite	eKmamp	weakly foliated amphibolite raft	amphibolite	18_crystalline
Basement (Median Batholith) igneous rocks	diorite	eKmed	Foliated to gneissic diorite with subordinate gabbro and minor ultramafic rocks	diorite	18_crystalline
Basement (Median Batholith) igneous rocks	gabbro	eKmgg	Massive to weakly folited (meta-) gabbro, gabbronorite & diorite; locally gneissic amphibolite; rare primary layering & dunite	gabbro	18_crystalline
Early Cretaceous sedimentary rocks	sandstone	eKmh	Indurated sandstone/mudstone, minor slump packets, pebbly mudstone and conglomerate.		15_undifSed
Early Cretaceous sedimentary rocks	conglomerate	eKmk	Indurated sandstone, conglomerate, breccia, siltstone.		15_undifSed
Basement (Median Batholith) igneous rocks	quartz monzodiorite	eKmki	Heterogeneous, fine-coarse, massive qtz diorite, qtz monzodiorite,diorite; subord tonalite & granodiorite;rare monzonite &gabbro	diorite	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Median Batholith) igneous rocks	diorite	eKmkid	Homogeneous, medium-coarse, variably foliated, equigranular, hornblende±pyroxene diorite, quartz diorite & quartz monzodiorite	diorite	18_crystalline
Basement (Median Batholith) igneous rocks	tonalite	eKmo	Fine to medium grained, equigranular, massive, biotite tonalite and minor granodiorite; abundant metasedimentary xenoliths	tonalite	18_crystalline
Basement (Eastern Province) melange	mudstone	eKmo	sheared siltstone to mudstone matrix with facoids of sandstone and concretionary blocks	melange	15_undifSed
Basement (Median Batholith) igneous rocks	granodiorite	eKmp	White, fine to medium gr, equigranular, massive, red-brown biotite granodiorite and granite; minor tonalite; metased xenoliths	granodiorite	18_crystalline
Early Cretaceous sedimentary rocks	sandstone	eKmt	Indurated conglomerate, breccia, sandstone, siltstone.		15_undifSed
Early Cretaceous sedimentary rocks	sandstone	eKmu	fine to medium sandstone, with minor grit, conglomerate and siltstone		15_undifSed
Basement (Median Batholith) igneous rocks	diorite	eKnoap	homogenous medium grained diorite; quartz monzodiorite and granodiorite	diorite pluton	18_crystalline
Basement (Median Batholith) metamorphic rocks	gneiss	eKnoapz	foliated and lineated diorite and granodiorite of North Arm Pluton	gneiss	18_crystalline
Basement (Median Batholith) igneous rocks	granite	eKnpg	Medium to coarse grained, equigranular, massive to locally foliated, biotite±muscovite granite and leucogranite	granite	18_crystalline
Cretaceous sedimentary rocks	breccia	eKo	breccia with Greenland Group clasts in maroon muddy sandstone matrix; sst, conglomerate, carbonaceous mst with lenses of coal	Otumotu Formation	15_undifSed
Basement (Median Batholith) igneous rocks	diorite	eKod	Medium gr, massive to foliated, hornblende diorite & gabbro, subordinate qtz diorite & tonalite; may include phases of older age	diorite	18_crystalline
Basement (Median Batholith) igneous rocks	tonalite	eKomg	Fine-medium grained, equigranular, variably foliated, bt±hbl tonalite, quartz monzodiorite and granodiorite; gneissic in places	tonalite	18_crystalline
Basement (Median Batholith) metamorphic rocks	orthogneiss	eKomg	Variably foliated to strongly banded, hbl-bio qtz diorite-qtz monzodiorite orthogneiss; minor granodiorite bands;coarse titanite	orthogneiss	18_crystalline

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Early Cretaceous sedimentary rocks	conglomerate	eKpo	Fluvial conglomerate and sandstone; locally hematitic	Pororari Group	05_fluvialEstuarine
Cretaceous sedimentary rocks	sandstone	eKpo+Kpc	Fluvial conglomerate and sandstone (locally hematitic) with coal seams and locally thick lacustrine mudstone	Pororari Group & Paparoa Coal M.	05_fluvialEstuarine
Early Cretaceous sedimentary rocks	sandstone	eKpob	Grey sandstone with carbonaceous lenses	Brown Grey Red-Green Formation	15_undifSed
Early Cretaceous sedimentary rocks	conglomerate	eKpoh	Breccia-conglomerate composed of varying proportions of granitoid rocks and Greenland Group	Hawks Crag Breccia	15_undifSed
Early Cretaceous sedimentary rocks	breccia	eKpol	Sandstone breccia; alternating sandstone and mudstone; and laminated carbonaceous mudstone'	Pororari Group (lower)	15_undifSed
Early Cretaceous sedimentary rocks	tuff	eKpos	Rhyolitic tuff	Stitts Tuff Member	15_undifSed
Early Cretaceous sedimentary rocks	sandstone	eKpou	Fluviatile feldspathic sandstone; carbonaceous siltstone; conglomerate; breccia	Pororari Group (upper)	15_undifSed
Basement (Median Batholith) igneous rocks	granodiorite	eKpp	Fine grained, equigranular, massive, granodiorite, granite, leucogranite and minor leucotonalite; isolated euhedral biotite	granodiorite	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	eKput	Medium gr, massive, mostly equigranular, bio±hbl granite, granodiorite & tonalite; subordinate qtz diorite & qtz monzodiorite	granodiorite	18_crystalline
Basement (Median Batholith) igneous rocks	granite	eKreg	Medium to coarse grained, massive, locally K-feldspar megacrystic, biotite granite; minor granodiorite and quartz monzonite	granite	18_crystalline
Basement (Median Batholith) metamorphic rocks	orthogneiss	eKrg	Homogeneous, variably foliated & lineated hornblende-plagioclase dioritic & gabbroic orthogneiss; hornblende granulite facies	orthogneiss	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	eKrh	Medium grained, massive, locally pink K-feldspar megacrystic, biotite-hornblende granodiorite and minor quartz monzodiorite	granodiorite	18_crystalline
Allochthonous rocks	sandstone	eKri	alternating sandstone/mudstone		15_undifSed
Basement (Median Batholith) igneous rocks	porphyry	eKripp	plagioclase-biotite-quartz-magnetite granodiorite porphyry plug and dikes	porphyry pluton	18_crystalline

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Allochthonous rocks	sandstone	eKri~	alternating sandstone/mudstone		15_undifSed
Allochthonous rocks	mudstone	eKrm	Indurated, and strongly deformed sandstone/mudstone, mudstone, sandstone, conglomerate (eKrc).		15_undifSed
Basement (Median Batholith) igneous rocks	tonalite	eKrog	Med gr, variably gneissic,foliated & lineated hbl-bio tonalite; subord qtz diorite, granodiorite & granite; conspicuous titanite	tonalite	18_crystalline
Basement (Median Batholith) igneous rocks	diorite	eKrolp	homogenous medium grained diorite; quartz monzodiorite and granodiorite	diorite pluton	18_crystalline
Allochthonous rocks	basalt	eKrr	Basalt, dolerite and tuff	submarine volcanics	18_crystalline
Allochthonous rocks	sandstone	eKrt	Indurated sandstone, conglomerate, breccia.		15_undifSed
Basement (Median Batholith) igneous rocks	diorite	eKrugsy	heterogeneous diorite; granodiorite; granite; microdiorite; andesite and basalt	diorite	18_crystalline
Basement (Median Batholith) metamorphic rocks	gneiss	eKrugsyz	foliated diorite; granodiorite and microdiorite of East Ruggedy Suite	gneiss	18_crystalline
Basement (Median Batholith) igneous rocks	gabbro	eKsads	heterogeneous dunite; norite; gabbro; anorthositic gabbro; and subordinate diorite	gabbro	18_crystalline
Basement (Median Batholith) metamorphic rocks	dioritic orthogneiss	eKsco	Well foliated & lineated, hbl-bio dioritic orthogneiss; locally includes metasediment sheets, banded amphibolite & felsic phases	orthogneiss	18_crystalline
Basement (Median Batholith) metamorphic rocks	orthogneiss	eKscom	Amphibolitic orthogneiss (Mt Vera Orthogneiss) with melanocratic & leucocratic phases on cm-10m scale; diorite-gabbro protolith	orthogneiss	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	eKsmop	medium massive biotite muscovite granodiorite and granite	granodiorite pluton	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	eKtarp	variably foliated fine to medium biotite ± muscovite granodiorite	granodiorite pluton	18_crystalline

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Basement (Median Batholith) igneous rocks	granodiorite	eKtg	Pale, massive, equigranular to K-feldspar megacrystic, biotite granodiorite, granite & leucogranite; garnet pegmatite dikes	granodiorite	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	eKtikp	massive to weakly foliated medium hornblende biotite titanite granodiorite and quartz monzodiorite	granodiorite pluton	18_crystalline
Basement (Median Batholith) igneous rocks	granite	eKukop	massive to foliated medium biotite muscovite garnet granite	granite pluton	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	eKurakp	massive fine biotite quartz monzodiorite; granodiorite; granite and leucogranite with pegmatite and alplite dikes	granite pluton	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	eKwahg	foliated granodiorite in Walkers PLuton	granodiorite	18_crystalline
Basement (Median Batholith) igneous rocks	monzodiorite	eKwahp	massive medium hornblende biotite ± clinopyroxene quartz monzodiorite and diorite; locally foliated	monzodiorite pluton	18_crystalline
Basement (Median Batholith) metamorphic rocks	gneiss	eKwahpz	foliated quartz monzodiorite and diorite of Walkers Hill Pluton	gneiss	18_crystalline
Basement (Median Batholith) igneous rocks	granite	eKwalg	Fine to med gr, massive, equigranular bio±gt leucogranite; subord leuco-granodiorite/tonalite; often >50% pegmatite	granite	18_crystalline
Basement (Median Batholith) igneous rocks	granite	eKwar	Intrusion breccia consisting of extensive West Arm Leucogranite dike network intruding Refrigerator Orthogneiss (as rafts)	granite	18_crystalline
Basement (Median Batholith) igneous rocks	diorite	eKwfoi	Pale,variably foliated-gneissic,two pyroxene±hbl diorite & monzodiorite; minor monzonite;rare gt reaction zones;granulite facies	orthogneiss	18_crystalline
Basement (Median Batholith) metamorphic rocks	orthogneiss	eKwfoia	Dark, med-gr, strongly foliated, hbl-rich dioritic orthogneiss (amphibolitic); completely retrogressed amphibolite metamorphism	orthogneiss	18_crystalline
Basement (Median Batholith) igneous rocks	diorite	eKwfoir	Variably foliated-gneissic, hbl diorite & qtz monzodiorite; relict granulite pyroxenes;partly retrogressed to amphibolite facies	orthogneiss	18_crystalline

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Basement (Median Batholith) igneous rocks	diorite	eKwfom	Variably foliated to gneissic, two pyroxene±hbl±gt diorite & monzodiorite; cut by garnet±cpx reaction zones; granulite facies	orthogneiss	18_crystalline
Basement (Median Batholith) metamorphic rocks	orthogneiss	eKwfoma	Med gr, strongly foliated, hbl-rich dioritic orthogneiss (amphibolitic); completely retrogressed amphibolite metamorphism	orthogneiss	18_crystalline
Basement (Median Batholith) igneous rocks	diorite	eKwfomr	Well foliated to gneissic, hbl diorite & monzodiorite; relict granulite clinopyroxene; partly retrogressed to amphibolite facies	orthogneiss	18_crystalline
Basement (Median Batholith) metamorphic rocks	gneiss	eKwforg	Hbl±bio mafic (?ortho)gneiss to hbl-bearing quartzofeldspathic (?para)gneiss; amphibolite facies; garnet-bearing leucosomes	gneiss	18_crystalline
Basement (Median Batholith) igneous rocks	diorite	eKwfow	Pale,weakly foliated to gneissic,two pyroxene±hbl diorite, monzodiorite & monzonite; rare gt±cpx reaction zones;granulite facies	orthogneiss	18_crystalline
Basement (Median Batholith) igneous rocks	diorite	eKwfowa	Variably folatied to gneissic, hbl diorite & monzodiorite;relict granulite pyroxene;partly retrogressed amphibolite metamorphism	orthogneiss	18_crystalline
Neogene sedimentary rocks	sandstone	eMa	Interbedded, massive or graded sandstone and mudstone.		15_undifSed
Neogene sedimentary rocks	sandstone	eMb	Massive to metre-bedded, grey to orange-brown, fine to medium sandstone with carbonaceous mudstone beds and rare thin coal seams		15_undifSed
Neogene sedimentary rocks	mudstone	eMbi	Grey-brown calcareous mudstone; locally with sandstone interbeds	Inangahua Formation	15_undifSed
Neogene sedimentary rocks	conglomerate	eMbr	Fluvial sandstone; conglomerate and lensoid coal seams	Rotokohu Coal Measures	05_fluvialEstuarine
Neogene sedimentary rocks	mudstone	eMbw	Grey-brown calcareous mudstone	Welsh Formation	15_undifSed
Neogene sedimentary rocks	sandstone	eMi	alternating sandstone and mudstone, massiveconcretionary mudstone and fine sandstone	undifferentiated early Miocene	15_undifSed
Neogene sedimentary rocks	limestone	eMiwkp	Dm-m bedded, graded, yellow, bioclastic fine-coarse calcareous sst or sandy limestone with mst interbeds; rare limestone breccia	limestone	15_undifSed

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Neogene sedimentary rocks	sandstone	eMiwop	Dm-bedded, graded, pale grey sandstone & calcareous mst; minor interbeds of coarse sandy pebble to boulder breccia &conglomerate	sandstone	15_undifSed
Neogene sedimentary rocks	limestone	eMiwv	graded bioclastic limestone interbedded with mudstone	limestone	15_undifSed
Neogene sedimentary rocks	limestone	eMiwv	Dm to cm bedded, graded, grey to yellow, bioclastic sandstone and sandy limestone with mudstone interbeds	limestone	15_undifSed
Paleogene - Neogene sedimentary rocks	limestone	eMk	Calcareous greensand and cemented bioclastic limestone		15_undifSed
Paleogene - Neogene sedimentary rocks	limestone	eMk	Calcareous greensand and cemented bioclastic limestone; locally with interbedded basalt flows or tuff. Sandstone in west	Mid-Tertiary lime-stone/greensand	15_undifSed
Paleogene - Neogene sedimentary rocks	limestone	eMk	limestone and greensand	limestone	15_undifSed
Paleogene - Neogene sedimentary rocks	sandstone	eMk+Mo	Siltstone, sandstone, carbonaceous mudtone, calcareous greensand and cemented bioclastic limestone		15_undifSed
Paleogene - Neogene sedimentary rocks	sandstone	eMk-eMn	Poorly exposed quartz sandstone at Haast Stream; South Ashburton catchment	Mid-Tertiary + early Miocene	15_undifSed
Paleogene - Neogene igneous rocks	basalt	eMk_b	Basaltic tuff and palagonitic basalt flows interbedded with limestone; locally pillow texture; commonly weathered	Mid-Tertiary basalt	18_crystalline
Paleogene sedimentary rocks	limestone	eMk_t	Cream indurated limestone; basaltic tuff; associated flow units and volcanogenic breccia	Mid-Tertiary limestone/basalt	15_undifSed
Neogene sedimentary rocks	sandstone	eMm	Grey-brown, muddy sandstone, mudstone , carbonaceous shale and thin coal seams.		15_undifSed
Neogene sedimentary rocks	sandstone	eMn	Grey, massive to well bedded or laminated, fine muddy sandstone with thin siltstone beds and conglomerate; common shell beds.		15_undifSed
Neogene sedimentary rocks	sandstone	eMn	Blue-grey to yellow-grey quartz sandstone and siltstone; commonly calcareous with tabular concretions	Early Miocene marine sed	15_undifSed

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Neogene sedimentary rocks	sandstone	eMn	Grey, massive to well bedded or laminated, fine muddy sandstone with thin siltstone beds and conglomerate; common shell beds and		15_undifSed
Neogene sedimentary rocks	sandstone	eMo	Grey to orange brown fine to medium sandstone with mudstone, carbonaceous shale and thin coal seams.		15_undifSed
Neogene sedimentary rocks	conglomerate	eMrl	Muddy sandstone and conglomerate containing indurated volcanogenic sandstone clasts	Lower Rappahannock Group	15_undifSed
Neogene sedimentary rocks	conglomerate	eMrl	Muddy sandstone and conglomerate containing indurated volcanogenic sandstone clasts	lower Rappahannock Group	15_undifSed
Neogene sedimentary rocks	mudstone	eMt	Mudstone, minor sandstone/mudstone.	Pukahika Mudstone	15_undifSed
Neogene sedimentary rocks	mudstone	eMt	Bioturbated, massive to weakly bedded mudstone with rare interbedded limestone.		15_undifSed
Neogene sedimentary rocks	mudstone	eMt	Mudstone, minor sandstone/mudstone.	Ngatapa Mudstone	15_undifSed
Neogene sedimentary rocks	mudstone	eMt	Calcareous mudstone, sandstone and conglomerate	Undifferentiated Early Miocene	15_undifSed
Neogene sedimentary rocks	mudstone	eMt	Bioturbated, massive to weakly bedded mudstone with local interbedded limestone.		15_undifSed
Neogene sedimentary rocks	mudstone	eMt	Mudstone, minor sandstone/mudstone.		15_undifSed
Neogene sedimentary rocks	sandstone	eMt+mMt	Sandstone, massive mudstone, sandy mudstone with minor concretionary limestone	Undifferentiated Early to Middl*	15_undifSed
Neogene sedimentary rocks	sandstone	eMta	alternating sandstone/mudstone	Rere Sandstone	15_undifSed
Neogene sedimentary rocks	sandstone	eMta	alternating sandstone/mudstone	"Cocos Flysch"	15_undifSed
Neogene sedimentary rocks	sandstone	eMta	alternating sandstone/mudstone		15_undifSed
Neogene sedimentary rocks	breccia	eMtb	sedimentary breccia		15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Neogene sedimentary rocks	conglomerate	eMtc	Igneous conglomerate.	Ihungia conglomerate	15_undifSed
Neogene sedimentary rocks	limestone	eMtk	Shelly limestone	Moonlight Limestone	15_undifSed
Neogene sedimentary rocks	limestone	eMtk	Shelly limestone	Kouetumarae Limestone	15_undifSed
Neogene sedimentary rocks	limestone	eMtl	Pebbly, fossiliferous limestone		15_undifSed
Neogene sedimentary rocks	limestone	eMtl	Limestone		15_undifSed
Neogene sedimentary rocks	mudstone	eMtm	Mudstone, basal conglomerate and limestone, tuff.	Whakai Formation	15_undifSed
Neogene sedimentary rocks	sandstone	eMtp	Glauconitic sandstone and mudstone with olistostrome deposits; tuffaceous towards the top		15_undifSed
Neogene sedimentary rocks	sandstone	eMts	muddy sandstone	marine (shelf) sandstone	15_undifSed
Neogene sedimentary rocks	sandstone	eMts	muddy sandstone		15_undifSed
Neogene sedimentary rocks	sandstone	eMts	muddy sandstone	Morunga Sandstone	15_undifSed
Neogene sedimentary rocks	sandstone	eMtv	Tuffaceous sandstone/mudstone	tuff beds	15_undifSed
Neogene sedimentary rocks	sandstone	eMtw	greensand	Whangara Sandstone	15_undifSed
Neogene sedimentary rocks	sandstone	eMtw	glauconitic sandstone	Whangara Sandstone	15_undifSed
Neogene sedimentary rocks	mudstone	eMt~	Mudstone, minor sandstone		15_undifSed
Neogene sedimentary rocks	mudstone	eMu	Massive to weakly bedded, sandy mudstone and muddy fine to medium sandstone.	Undifferentiated Mokau Group and Manganui Formation	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Western Province) metamorphic rocks	psammite	eOrf	Variably schistose psammite with minor pelite and amphibolite; occurs as raft in pluton	psammite	18_crystalline
Basement (Western Province) metamorphic rocks	metasandstone	eOrf	Massive metasandstone/psammite and subordinate quartzite	metasandstone	18_crystalline
Basement (Western Province) metamorphic rocks	metasandstone	eOrf	Massive to weakly foliated, greenschist facies, fine to medium gr, quartzose metasandstone with minor metamudstone	metasandstone	18_crystalline
Basement (Western Province) metamorphic rocks	psammite	eOrf	Schistose psammite with subordinate pelite; minor quartzite and calc-silicate	psammite	18_crystalline
Basement (Western Province) metamorphic rocks	metasandstone	eOrf	Metasandstone/non-schistose psammite with subordinate biotite±sillimanite±staurolite schistose semi-pelite & pelite	metasandstone	18_crystalline
Basement (Western Province) metamorphic rocks	metasandstone	eOrf	Metasandstone & minor graphitic metamudstone interbedded with quartzites (?Burnett Fmn)	metasandstone	18_crystalline
Basement (Western Province) metamorphic rocks	psammite	eOrf	Variably schistose psammite with minor pelite, quartzite, calc-silicate and marble; occurs as raft in pluton	psammite	18_crystalline
Basement (Western Province) metamorphic rocks	psammite	eOrf	Variably schistose psammite with minor pelite, calc-silicate, marble and amphibolite; occurs as raft in pluton	psammite	18_crystalline
Basement (Western Province) metamorphic rocks	metasandstone	eOrf	Metasandstone & minor graphitic metamudstone interbedded with quartzites (?Burnett Fmn);grades east to psammitic &pelitic schist	metasandstone	18_crystalline
Basement (Western Province) metamorphic rocks	quartzite	eOrfb	Massive and thick pale grey quartzite interbedded with thin bedded graphitic metamudstone; rare marble and calc-silicates	quartzite	18_crystalline
Basement (Western Province) metamorphic rocks	pelite	eOrff	Laminated to thin-bedded graphitic to non-graphitic pelite & semi-pelite; two thick quartzites occur in middle of sequence	pelite	18_crystalline
Basement (Western Province) metamorphic rocks	metamudstone	eOrfg	Dark grey to black, finely laminated to massive graphitic metamudstone; rare quartzite around Mt Edgecumbe	metamudstone	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Western Province) metamorphic rocks	metasandstone	eOrfl	Thick-bedded quartzose metasandstone & pelite or semi-pelite (as turbidites); lacks graphite; minor quartzite; rare marble	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	quartzite	eOrfl	Thin-bedded quartzite, calc-silicates and marble; graphitic semi-pelite and rare pelite; overlies Lumaluma Fmn turbidites	metasediment	18_crystalline
Basement (Western Province) metamorphic rocks	metasandstone	eOrfp	Well bedded quartz-rich metasandstone & both graphitic & non-graphitic metamudstone; subordinate quartzite; locally graptolitic	metasediment	18_crystalline
Neogene igneous rocks	andesite	ePat	Andesite with subordinate dacite and rhyolite ignimbrite and tuff		18_crystalline
Neogene igneous rocks	andesite	ePcp	Andesite and dacite commonly jointed lava; intervening thin red volcanic breccia		18_crystalline
Neogene igneous rocks	andesite	ePlmo	Pyroxene andesitic jointed lavas; minor volcanic breccia		18_crystalline
Neogene sedimentary rocks	sandstone	ePm	Calcareous sandstone, mudstone, pebbly limestone and conglomerate	Undifferentiated Early Pliocene	15_undifSed
Neogene sedimentary rocks	limestone	ePmk	Yellow-grey, barnacle-rich, sandy limestone and cross-bedded sandstone		15_undifSed
Neogene sedimentary rocks	limestone	ePmm	shelly sandy limestone	Ormond Limestone	15_undifSed
Neogene sedimentary rocks	limestone	ePmo	Sandy shelly limestone	Opoiti Limestone?	15_undifSed
Neogene sedimentary rocks	limestone	ePmo	Sandy shelly limestone.	Opoiti Limestone	15_undifSed
Neogene sedimentary rocks	limestone	ePmp	Well cemented limestone, conglomerate and sandstone	limestone	15_undifSed
Neogene sedimentary rocks	sandstone	ePms	calcareous sandstone		15_undifSed
Neogene sedimentary rocks	limestone	ePmw	Sandy limestone with coquina beds.	Whakapunake Limestone	15_undifSed
Neogene sedimentary rocks	limestone	ePmw~	sandy shelly limestone		15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Neogene sedimentary rocks	mudstone	ePmz	Siltstone, sandstone, tuff beds.		15_undifSed
Neogene sedimentary rocks	mudstone	ePmz~	Siltstone, sandstone, tuff beds.		15_undifSed
Early Pleistocene river deposits	gravel	eQa	Slightly to moderately weathered, muddy to sandy gravel in outwash terrace remnants; dissected	Old to very old outwash	12_outwash
Early Pleistocene river deposits	gravel	eQa	Slightly - highly weathered mixtures of gravel+sand+silt+clay forming dissected river terrace/plateaux remnants	Very old river alluvium/outwash	12_outwash
Neogene sedimentary rocks	sand	eQa	Mainly pumiceous alluvium and colluvium with interbedded peat		15_undifSed
Neogene sedimentary rocks	sand	eQa	Pumiceous mud, silt, sand, and gravel with muddy peat beds		15_undifSed
Early Pleistocene river deposits	gravel	eQa	Mixed angular schist and rounded quartz gravel, sand and boulders in former channels of Taieri River	alluvium	06_alluvium
Early Pleistocene river deposits	gravel	eQa	Very weathered clay bound gravel deposits forming relict high aggradation terraces overtopped by loess and fan gravels	alluvial deposits	06_alluvium
Early Pleistocene - Middle Pleistocene undifferentiated estuary, river and swamp deposits	sand	eQa	Partly consolidated sand, mud and peat of estuarine, swamp, alluvial and colluvial origins.	estuarine, swamp and alluvial	15_undifSed
Middle Pleistocene - Late Pleistocene river deposits	gravel	eQa	weathered greywacke- and schist-derived gravel	terrace alluvium	16_terrace
Early Pleistocene river deposits	gravel	eQac	deeply weathered greywacke - quartz gravel and sand in high terrace west of Clydevale	terrace gravels	16_terrace
Early Pleistocene river deposits	gravel	eQac	Deeply weathered, clayey sandy gravel with mainly Rakaia terrane-derived sandstone & minor schist, qtz, lamprophyre clasts	alluvium	06_alluvium
Early Pleistocene river deposits	gravel	eQaf	weathered sandy gravel in very old fans	alluvial fans	10_fan
Early Pleistocene river deposits	gravel	eQaf	Strongly weathered schist gravel and sand in elevated fans of upper Mataura River	alluvial fan	10_fan

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Early Pleistocene river deposits	gravel	eQaf	Poorly sorted, weathered steep fan gravel deposits	fan deposits	10_fan
Early Pleistocene river deposits	gravel	eQag	deeply weathered greywacke - quartz gravel and sand in high terrace north of Gore	terrace gravels	16_terrace
Early Pleistocene - Middle Pleistocene river and igneous deposits	ignimbrite	eQai	Alluvium dominated by primary and reworked, non-welded ignimbrite.	Alluvial deposits dominated by p	06_alluvium
Early Pleistocene igneous rocks	ignimbrite	eQak	Non-welded pumice tuffs and sandstone		18_crystalline
Early Pleistocene river deposits	gravel	eQal	deeply weathered clay-rich sandy gravel in degraded high terrace remnants	alluvial terraces	16_terrace
Early Pleistocene river deposits	gravel	eQal	pumiceous sand and gravel	alluvial deposits	06_alluvium
Neogene sedimentary rocks	sand	eQal	Pumiceous mud, silt, sand and gravel with muddy peat beds; rhyolite pumice, including non-welded ignimbrite, tephra and alluvial	Alluvial and colluvial deposits	15_undifSed
Early Pleistocene river deposits	gravel	eQal	Poorly to moderately sorted gravel with minor boulders, sand and silt underlying terraces; includes minor fan deposits and loess	alluvial terrace deposits	16_terrace
Early Pleistocene river deposits	gravel	eQal	Weathered; poorly sorted loess-covered fan gravel; alluvial gravel and lacustrine silt deposits; including Te Muna Formation		06_alluvium
Early Pleistocene river deposits	gravel	eQal	Alluvial gravel, sand and silt comprising terraces; includes minor fan deposits and loess	alluvial terrace deposits	16_terrace
Early Pleistocene river deposits	gravel	eQal	Weathered and locally cemented river gravel and sand		06_alluvium
Early Pleistocene - Middle Pleistocene undifferentiated estuary, river and swamp deposits	mud	eQal	Partly consolidated mud, sand, gravel and peat or lignite of alluvial, colluvial, lacustrine, swamp and estuarine origins.	alluvium	15_undifSed
Early Pleistocene river deposits	gravel	eQal	Fan deposits	alluvial fan deposits	10_fan

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Early Pleistocene river and estuary deposits	gravel	eQal	Gravels, sands, silts, muds,; minor ignimbrite and tephra.		06_alluvium
Early Pleistocene river deposits	gravel	eQal	Moderately to strongly weathered, clayey sandy sandstone-schist gravel in isolated terrace remnants	alluvium	06_alluvium
Late Pleistocene river and lake deposits	gravel	eQam	lacustrine and fluvial sediments	alluvium	06_alluvium
Early Pleistocene lahar deposits	conglomerate	eQamt	Laharic conglomerate	lahars	15_undifSed
Neogene sedimentary rocks	sand	eQat	Rhyolitic terrace deposits around Tauranga Harbour		15_undifSed
Early Pleistocene river deposits	gravel	eQat	alternating gravel, loess and mudstone	alluvium	06_alluvium
Early Pleistocene shoreline deposits	sand	eQb	Weathered and locally cemented marine sand and gravel		15_undifSed
Early Pleistocene windblown deposits	sand	eQd	Weakly cemented and uncemented quartzofeldspathic to mafic-rich, dune-bedded sand and clay-rich sandy paleosols, with lenses of	Older parabolic dunes	11_loess
Early Pleistocene windblown deposits	sand	eQd	Weakly cemented and partly consolidated sand in fixed parabolic dunes, capped by clay-rich sandy soils.	Older parabolic dunes	11_loess
Early Pleistocene - Middle Pleistocene windblown deposits	sand	eQdf	Uncemented to moderately cemented and partly consolidated sand in coastal foredunes. Clay-rich sandy soils.	consolidated coastal dunes	11_loess
Early Pleistocene - Middle Pleistocene windblown deposits	sand	eQdf	Dune belts of arcuate, subparallel, weakly cemented and uncemented sand ridges, often capped by cemented, clay-rich sandy paleos	Coastal foredunes	11_loess
Early Pleistocene windblown deposits	sand	eQdp	Weakly cemented and partly consolidated sand in parabolic dunes. Interdune lake and swamp deposits.	consolidated parabolic dunes	11_loess
Early Pleistocene windblown deposits	sand	eQdp	Weakly cemented and uncemented quartzofeldspathic to mafic-rich, dune-bedded sand and clay-rich sandy paleosols, with lenses of	Parabolic dunes	11_loess
Early Pleistocene lahar deposits	debris	eQho	Laharic breccia of andesite cobbles overlying sandstone and conglomerate beach deposits	Old Fm over Q13 beach deposits	09_beachBarDune
Early Pleistocene igneous rocks	ignimbrite	eQi	blocky, jointed ignimbrite	undifferentiated early Quaterna*	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Early Pleistocene sedimentary rocks	mud	eQi	Unconsolidated to slightly consolidated, laminated mud (with scattered dropstones) and sand; pebbly gravel; rare till	mud	15_undifSed
Early Pleistocene - Middle Pleistocene river deposits	sand	eQk	Highly weathered, coarse pumiceous and rhyolitic sands and current-bedded grits, with interbedded peat and local gravels.		06_alluvium
Early Pleistocene sedimentary rocks	mudstone	eQk	Sandstone, siltstone, bioclastic limestone, conglomerate and pumiceous sand		15_undifSed
Early Pleistocene sedimentary rocks	sandstone	eQk	Coarse pumice grit, tephra, sand, silt, shellbeds and conglomerate		15_undifSed
Middle Pleistocene river deposits	conglomerate	eQl	Poorly-sorted, cemented and weakly stratified ultramafic-derived gravel.	Plateau Gravel	06_alluvium
Early Pleistocene igneous rocks	andesite	eQlt	Pyroxene andesite lava; scarce olivine; minor tephra		18_crystalline
Early Pleistocene sedimentary rocks	sandstone	eQmk	Coarse calcareous sandstone, limestone and conglomerate		15_undifSed
Early Pleistocene igneous rocks	ignimbrite	eQms	Three ignimbrite units; non-welded to sintered; lower (G) includes orange-brown pumice, (H) middle rich in pumice; (I) upper vap		18_crystalline
Late Pliocene - Pleistocene igneous rocks	andesite	eQmt	olivine basalt, and andesite, lavas and dikes; amphibole andesite lava flow		18_crystalline
Early Pleistocene igneous rocks	andesite	eQmw	Andesite lava	[And Awakaponga formation]	18_crystalline
Early Pleistocene sedimentary rocks	mudstone	eQo	Sandstone, siltstone, conglomerate and shell beds		15_undifSed
Early Pleistocene sedimentary rocks	sandstone	eQo	Sandstone, siltstone, conglomerate and shell beds		15_undifSed
Early Pleistocene river deposits	gravel	eQp	Moderately well sorted gravel including up to boulder-sized clasts of quartzofeldspathic sandstone	Porika Formation	06_alluvium
Early Pleistocene igneous rocks	ignimbrite	eQp	mostly or wholley Ongatiti, Mangaokewa and/or Raepahu formations of silicic ignimbrite		18_crystalline
Early Pleistocene river deposits	gravel	eQp	Moderately well sorted gravel including up to boulder-sized clasts of quartzofeldspathic sandstone	Cover	06_alluvium

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Early Pleistocene river, lake and shoreline deposits	gravel	eQp	lacustrine and fluvial sediments	alluvium	06_alluvium
Early Pleistocene igneous rocks	ignimbrite	eQp	Partially welded, pumice- and crystal-rich ignimbrite with inverse thermal zonation; lithics of rhyolite, andesite and densely w	Te Puna ig or Raepahu Fm	18_crystalline
Early Pleistocene igneous rocks	ignimbrite	eQpa	Ignimbrite with inverse thermal zonation; a non-welded base grades up through moderately welded material to a densely welded and		18_crystalline
Early Pleistocene igneous rocks	ignimbrite	eQpb	Welded vapour phase altered recrystallised silicic ignimbrite; lithics of andesite and greywacke only	Tolley formation	18_crystalline
Early Pleistocene igneous rocks	ignimbrite	eQpc	Non-welded to very welded fiamme-bearing andesitic ignimbrite; lithics up to 40% and greater than 1m diameter	Pouakani formation	18_crystalline
Early Pleistocene igneous rocks	ignimbrite	eQpl	Densely welded crystal rich fine-grained ignimbrite, poor in visible pumice or lithics	Link formation	18_crystalline
Early Pleistocene igneous rocks	ignimbrite	eQpm	Partially welded ignimbrite with inverse thermal zonation; jointed highly welded top; rhyolite and greywacke lithics	includes Unit D and Ahuroa ig	18_crystalline
Early Pleistocene igneous rocks	ignimbrite	eQpn	Partly welded, pumice-rich ignimbrite, usually with extensive vapour-phase alteration and recrystallised chalky texture.		18_crystalline
Early Pleistocene igneous rocks	ignimbrite	eQpn	Eutaxitic silicic ignimbrite	also Unit A	18_crystalline
Early Pleistocene igneous rocks	ignimbrite	eQpo	Compound, weakly to strongly welded, vitrophyric, pumice- and crystal-rich ignimbrite with abundant lithics		18_crystalline
Early Pleistocene igneous rocks	ignimbrite	eQpo	Compound, moderately to strongly welded, vitriophyric pumice and crystal rich ignimbrite with abundant lithics.		18_crystalline
Early Pleistocene igneous rocks	ignimbrite	eQpr	Pumice-rich ignimbrite with inverse thermal zonation; a thick partially welded base is capped by a thin densely welded ignimbrit		18_crystalline
Early Pleistocene igneous rocks	ignimbrite	eQpr	Partially welded, pumice- and crystal-rich ignimbrite with inverse thermal zonation; lithics of rhyolite, andesite and densely w		18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Early Pleistocene igneous rocks	ignimbrite	eQpt	Moderately welded to lenticulite, ignimbrite; rhyolitic crystal poor Pukerimu unit; mid-grey to black mod xtals Tikorangi unit	Pukerimu and Tikorangi ig	18_crystalline
Early Pleistocene igneous rocks	ignimbrite	eQr	bedded fall deposits and crystal-rich, non-welded ignimbrite with conspicuous biotite		18_crystalline
Early Pleistocene igneous rocks	ignimbrite	eQrp	Grey brown ignimbrite with unusually abundant hornblende; patches intensely red from vapour phase alteration		18_crystalline
Early Pleistocene glacier deposits	till	eQt	lag deposits of greywacke gravels; weathered clayey bouldery till and gravel	till	14_moraineTill
Early Pleistocene glacier deposits	till	eQt	bouldery to clay rich till in a complex of moraine remnants west of Alpine Fault	till	14_moraineTill
Early Pleistocene glacier deposits	till	eQt	Weakly weathered, bouldery to clay-rich till in complex of moraine remnants west of Alpine F; partly overlies marine silt (eQm)	Old to very old till	14_moraineTill
Early Pleistocene glacier deposits	till	eQt	Weakly weathered, bouldery sandy till; distorted laminated sand & sandy gravel lenses; bouldery lag; rare carbonaceous silt	Old to very old till	14_moraineTill
Early Pleistocene glacier deposits	till	eQt	Weakly weathered, bouldery to clay-rich till in complex of moraine remnants west of Alpine Fault	Old to very old till	14_moraineTill
Early Pleistocene glacier deposits	till	eQt	Weakly weathered, bouldery sandy till	Old to very old till	14_moraineTill
Early Pleistocene glacier deposits	gravel	eQt	Weathered and locally cemented till	glacial deposits	14_moraineTill
Early Pleistocene glacier deposits	gravel	eQt	Weathered and locally cemented till		14_moraineTill
Early Pleistocene glacier deposits	till	eQte	Slightly weathered bouldery silty gravel(till) in Nevis Valley	till	14_moraineTill
Early Pleistocene sedimentary rocks	gravel	eQu	Beach deposits consisting of marine gravel, sand and mud in marine bench	eQ-mQ marine and alluvial	15_undifSed
Neogene igneous rocks	tephra	eQu	Weathered, clay-rich, multiple tephra deposits and associated paleosols.		18_crystalline
Early Pleistocene sedimentary rocks	mudstone	eQu	Sandstone, mudstone, silicic tephra	marine, alluvial and tephra	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Early Pleistocene river and lake deposits	gravel	eQu	Undifferentiated Early Quaternary deposits		10_fan
Early Pleistocene igneous rocks	rhyolite	eQur	Rhyolite lava	rhyolite lava	18_crystalline
Early Pleistocene igneous rocks	basalt	eQvb	Basalt scoria		18_crystalline
Early Pleistocene igneous rocks	andesite lava	eQvh	Weathered, brown andesite to basaltic andesite lava, pyroclastic breccia and tuff		18_crystalline
Late Pliocene - Pleistocene igneous rocks	andesite	eQvpu	Pyroxene andesite lava; minor tephra		18_crystalline
Early Pleistocene igneous rocks	andesite	eQvr	Andesite lava		18_crystalline
Early Pleistocene igneous rocks	andesite lava	eQvsl	Hornblende andesite lava and breccia		18_crystalline
Early Pleistocene igneous rocks	ignimbrite	eQwi	Intensely welded, crystal-poor, sub-vertically jointed, grey to brown lenticular ignimbrite with long distorted glassy fiamme		18_crystalline
Early Pleistocene igneous rocks	ignimbrite	eQwi	Intensely welded, crystal-poor, sub-vertically jointed, grey to brown lenticular ignimbrite with long distorted glassy fiamme	[Ongaroto Group?]	18_crystalline
Early Pleistocene igneous rocks	rhyolite	eQwr	Hypersthene-clinopyroxene rhyolite lava		18_crystalline
Early Pleistocene igneous rocks	tuff	eQx	Non-welded quartz-rich pumiceous tephra, likely ignimbrite	Unit X [Nairn, 2002]	18_crystalline
Basement (Eastern Province) igneous rocks	granite	eTcg	biotite granite to granodiorite	granite	18_crystalline
Basement (Eastern Province) igneous rocks	diorite	eTod	meladiorite on gabbro margins	diorite	18_crystalline
Basement (Eastern Province) melange	sandstone	eTth	fault zone melange of early Triassic sandstone deformed by Cenozoic to Recent faulting	melange	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Early Pleistocene river deposits	gravel	emQa	Slightly - highly weathered mixtures of gravel+sand+silt+clay forming dissected river terrace/plateaux remnants	Very old river alluvium/outwash	12_outwash
Early Pleistocene river deposits	gravel	emQa	Yellow brown, slightly-highly weathered gravel/sand/silt/clay mixtures; forms highest remnant river terraces; loess cap	Very old river alluvium/outwash	12_outwash
Early Pleistocene - Middle Pleistocene river deposits	gravel	emQal	gravel; sand; silt and rare peat beneath Hellfire Formation in northern Freshwater valley	alluvial terraces	16_terrace
Basement (Eastern Province) sedimentary rocks	siltstone	emTn	well bedded siltstone; sandstone; tuff; shellbeds and conglomerate	siltstone	15_undifSed
Basement (Eastern Province) sedimentary rocks	siltstone	emTn	well bedded siltstone sandstone tuff shellbeds and conglomerate	siltstone	15_undifSed
Basement (Eastern Province) sedimentary rocks	conglomerate	emTnc	massive to metre-bedded conglomerate with sandstone and red and green siltstone interbeds	conglomerate	15_undifSed
Basement (Eastern Province) sedimentary rocks	siltstone	emTns	siltstone with minor fine sandstone	siltstone	15_undifSed
Basement (Eastern Province) melange	limestone	emYler	fault zone melange of Permian sediments deformed during Mesozoic thrusting	melange	15_undifSed
ice		ice			00_ICE
ice		ice	glaciers; snowfields		00_ICE
Basement (Median Batholith) igneous rocks	syenite	lCabigp	massive medium to coarse quartz syenite and alkali feldspar granite	syenite pluton	18_crystalline
Basement (Median Batholith) igneous rocks	granite	lCafoco	alkali feldspar granite and quartz syenite	granite	18_crystalline
Basement (Median Batholith) igneous rocks	syenite	lCafrdp	massive medium to coarse quartz syenite and alkali feldspar granite	syenite	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Median Batholith) metamorphic rocks	orthogneiss	lCmjgg	Pale grey, fine-medium grained, variably to strongly foliated, biotite-magnetite±gt granodiorite to tonalite gneiss;no xenoliths	gneiss	18_crystalline
Basement (Median Batholith) metamorphic rocks	orthogneiss	lCmjgg	Pale grey, fine-medium grained, variably to strongly foliated, biotite-magnetite granodiorite to tonalite gneiss; no xenoliths	gneiss	18_crystalline
Basement (Median Batholith) metamorphic rocks	orthogneiss	lCmjgg	Medium grained, variably foliated, biotite±magnetite±gt granodiorite; contains massive to schistose amphibolite xenoliths	gneiss	18_crystalline
Basement (Western Province) metamorphic rocks	calc-silicate	lCmtc	Thin-bedded psammite and calc-silicate; subordinate calcic psammitic schist & mafic hornblende-biotite schist; minor thin marble	calc-silicate	18_crystalline
Basement (Median Batholith) igneous rocks	diorite	lDdic	Hornblende-biotite diorite, quartz diorite, tonalite; minor granodiorite and granite	diorite	18_crystalline
Basement (Median Batholith) igneous rocks	diorite	lDdic	Hornblende-biotite diorite, quartz diorite, tonalite; minor granodiorite and granite; ultramafic xenoliths	diorite	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	lDeCa77	Med-coarse grained, weakly to strongly foliated, equigranular, red-brown biotite±gt±hbl tonalite & granodiorite	granodiorite	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	lDeCa77	Med-coarse grained, weakly to moderately foliated, equigranular, red-brown biotite±gt±hbl tonalite & granodiorite, minor granite	granodiorite	18_crystalline
Basement (Median Batholith) igneous rocks	tonalite	lDeCa77	Medium grained, moderately foliated to gneissic, equigranular, red-brown biotite±hbl tonalite to granodiorite	tonalite	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	lDeCabp	Med-coarse gr, massive-weakly foliated, equi, rarely megacrystic, bio±ms±gt granodiorite & granite, minor tonalite, rare syenite	granodiorite	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	lDeCajp	Med-coarse gr, massive-weakly foliated, equigranular, biotite granodiorite & granite, minor tonalite; many xenoliths	granodiorite	18_crystalline
Basement (Median Batholith) igneous rocks	granodiorite	lDmsg	Pale, medium grained, massive to weakly foliated, biotite±hornblende leucogranodiorite and minor tonalite	granodiorite	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Paleogene sedimentary rocks	sandstone	lEh	quartz sandstone and quartz conglomerate with lignite	quartz sandstone	15_undifSed
Paleogene sedimentary rocks	sandstone	lEh	non-marine quartz pebble conglomerate (locally silica-cemented) sandstone siltstone mudstone coal	quartz sandstone	15_undifSed
Paleogene sedimentary rocks	quartzite	lEhc	hard silica-cemented quartz sandstone and conglomerate	quartzite	15_undifSed
Basement (Median Batholith) igneous rocks	granite	lJCodp	massive medium biotite granite foliated adjacent to major faults	granite pluton	18_crystalline
Basement (Eastern Province) sedimentary rocks	siltstone	lJa	Siltstone, sandstone and conglomerate, carbonaceous near top.		15_undifSed
Basement (Median Batholith) igneous rocks	granite	lJaeg	Medium-coarse grained, variably foliated to gneissic, pink K-feldspar porphyritic, green-brown biotite granite & granodiorite	granite	18_crystalline
Basement (Median Batholith) metamorphic rocks	diorite	lJak	Heterogeneous, foliated & lineated, gneissic, equigranular, hornblende-biotite diorite, quartz diorite, tonalite & granodiorite	orthogneiss	18_crystalline
Basement (Median Batholith) igneous rocks	granite	lJakg	Coarse grained, variably foliated, K feldspar porphyritic, biotite±gt granite & granodiorite; minor diorite	granite	18_crystalline
Basement (Median Batholith) igneous rocks	granite	lJakg	Variably to strongly foliated & lineated (gneissic), equigranular, biotite granite & granodiorite; minor tonalite & diorite	granite	18_crystalline
Basement (Median Batholith) igneous rocks	granite	lJchg	Leucocratic, pink-white, med-coarse gr, massive, equigranular biotite (as clots) granite; thin mylonitic zones on western margin	granite	18_crystalline
Basement (Eastern Province) sedimentary rocks	siltstone	lJh	Carbonaceous siltstone, sandstone and conglomerate with abundant plant fragments and rare thin coals.		15_undifSed
Basement (Eastern Province) sedimentary rocks	siltstone	lJh	Alternating siltstone, sandstone and conglomerate with abundant plant fragments and rare thin coals: predominantly non-marine.		15_undifSed
Basement (Median Batholith) igneous rocks	gabbro	lJhilu	Gabbro with a pluton core of troctolite, dunite, hbl-dunite, olivine anorthosite, olivine gabbro; massive and layered cumulates	gabbro	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Median Batholith) igneous rocks	syenogranite	lJpig	NNE-striking dike swarm of pink, fine-med grained, massive, equigranular, biotite leuco-syenogranite	granite	18_crystalline
Basement (Median Batholith) igneous rocks	syenogranite	lJpig	Pink-white, med-coarse gr, massive to strongly foliated & lineated bio±gt leuco-syenogranite; minor monzogranite & granodiorite	granite	18_crystalline
Basement (Median Batholith) metamorphic rocks	dioritic orthogneiss	lJscg	Gneissic hornblende diorites and garnet-biotite gneiss; intruded by abundant amphibolitic to felsic dikes	orthogneiss	18_crystalline
Late Cretaceous - Paleogene sedimentary rocks	sandstone	lK	Quartzose pebbly sst with mst & rare coal seams (Tauperikaka), massive sst and mst (Whakapohai), basaltic lava & tuff (Arnott)	Late Cretaceous undifferentiated	15_undifSed
Late Cretaceous - Paleogene sedimentary rocks	sandstone	lKEe	Undifferentiated sandstone and siltstone, commonly glauconitic and slightly calcareous with conglomerate and pebbly sandstone.	undifferentiated Eyre Group	15_undifSed
Late Cretaceous - Paleogene sedimentary rocks	sandstone	lKEe_	Undifferentiated sandstone and siltstone, commonly glauconitic and slightly calcareous with conglomerate and pebbly sandstone.	undifferentiated Eyre Group	15_undifSed
Late Cretaceous - Paleogene sedimentary rocks	siltstone	lKPe	Marine, dark grey, massive, jarositic, concretionary sandy siltstone & sandstone, locally contains KT boundary at very top	Conway Formation	15_undifSed
Late Cretaceous - Paleogene sedimentary rocks	sandstone	lKPe	Non-marine coal measures at base, overlain by marine siltstone, mudstone, and greensand; grouped for cartographic reasons	Undiff Eyre Group	15_undifSed
Late Cretaceous sedimentary rocks	limestone	lKPz	Undifferentiated indurated micritic limestone, calcareous mudstone and chert.	undifferentiated Muzzle Group	15_undifSed
Late Cretaceous igneous rocks	basalt	lKa	Plagioclase-phyric basaltic lava flows and breccia with lenses of tuff	Arnott Basalt	18_crystalline
Late Cretaceous sedimentary rocks	conglomerate	lKb	Conglomerate with boulders of andesite & dacite, Greenland Gp metasedimentary rock. Interbedded flows of trachyandesite & dacite	Buttress Point Conglomerate	15_undifSed
Late Cretaceous sedimentary rocks	conglomerate	lKb	schist-derived breccia conglomerate and minor sandstone usually strongly weathered locally auriferous	schist conglomerate	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Cretaceous sedimentary rocks	conglomerate	lKbc	Poorly sorted conglomerate containing igneous clasts, with interbedded sandstone, siltstone, mudstone and sparse coal lenses.	Beebys Conglomerate	15_undifSed
Late Cretaceous sedimentary rocks	sandstone	lKc	Moderately indurated conglomerate, sandstone, siltstone and mudstone	undiff. Coverham Group	15_undifSed
Early Cretaceous sedimentary rocks	sandstone	lKcc	Torlesse-derived conglomerate, sandstone and mudstone; in general highly deformed	Champagne Formation	15_undifSed
Late Cretaceous sedimentary rocks	sandstone	lKcg	Indurated conglomerate, sandstone, siltstone and mudstone	Gladstone Formation	15_undifSed
Late Cretaceous sedimentary rocks	sandstone	lKcs	Mass flow conglomerate, siltstone and mudstone; sandstone and interbedded sandstone and mudstone	Split Rock Formation	15_undifSed
Late Cretaceous sedimentary rocks	sandstone	lKcs_	Mass flow conglomerate, siltstone and mudstone; sandstone and interbedded sandstone and mudstone	undifferentiated late Early and	15_undifSed
Late Cretaceous sedimentary rocks	siltstone	lKcw	Moderately indurated, mildly deformed conglomerate and siltstone	Winterton Formation	15_undifSed
Late Cretaceous - Paleogene sedimentary rocks	sandstone	lKe	Marine, sandy siltstone & sandstone (Conway); non-marine quartzose sst; local congl, carb mst, & thin coal at base(Broken River)	Undiff Broken River/Conway fmns	15_undifSed
Late Cretaceous - Paleogene sedimentary rocks	siltstone	lKe	Massive, grey, fine-grained siltstone to very fine sandstone; large concretions common	lower Eyre Group	15_undifSed
Late Cretaceous - Paleogene sedimentary rocks	claystone	lKe_b	Carbonaceous and quartzose claystone mudstone and sandstone; local coal seams	Cretaceous quartz coal measures	15_undifSed
Late Cretaceous sedimentary rocks	sandstone	lKeb	Non-marine, qtz sst; carb mst & claystone; minor congl. & coal seams (some thick) mainly nr base.Marine influence (glau) nr top	Broken River Formation	15_undifSed
Late Cretaceous sedimentary rocks	sandstone	lKeb	Non-marine qtz sst; carb mst & claystone; minor congl. and thin coal seams, mainly near base. Marine influence (glau) near top	Broken River Formation	15_undifSed
Late Cretaceous sedimentary rocks	sandstone	lKeb	Non-marine, quartzose fine sst; carbonaceous mst; local conglomerate & thin coal seams near base. Marginal marine(glau) near top	Broken River Formation	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Western Province) igneous rocks	granite	lKg	Biotite granite; lineated & locally foliated; intensely sheared and cataclased; contains acid & basic dykes	Late Cretaceous granite	18_crystalline
Late Cretaceous sedimentary rocks	breccia	lKh	non-marine breccia conglomerate and sandstone minor coal	schist breccia	15_undifSed
Late Cretaceous sedimentary rocks	conglomerate	lKhb	Poorly-sorted, clast-supported conglomerate, pebbly mudstone, sandstone and alternating sandstone-siltstone	Burnt Creek Formation	15_undifSed
Late Cretaceous sedimentary rocks	conglomerate	lKhb_	Poorly-sorted, clast-supported conglomerate, pebbly mudstone, sandstone and alternating sandstone-siltstone	undifferentiated late Early and	15_undifSed
Late Cretaceous sedimentary rocks	siltstone	lKhn	Faintly-bedded, purple-brown siltstone to very fine sandstone, commonly glauconitic and burrowed	Nidd Formation	15_undifSed
Late Cretaceous sedimentary rocks	breccia	lKik	Breccia in mudstone matrix.	marine debris flow deposits	15_undifSed
Late Cretaceous sedimentary rocks	sandstone	lKio	Alternating glauconitic sandstone, mudstone		15_undifSed
Late Cretaceous sedimentary rocks	siltstone	lKit	Siltstone with glauconitic microbreccia, minor sandstone/mudstone, conglomerate.		15_undifSed
Late Cretaceous sedimentary rocks	conglomerate	lKm_m	Interbedded well-rounded pebble to cobble conglomerate; grit; mudstone and coal beds	Cretacous rhyolite conglomerate	15_undifSed
Late Cretaceous sedimentary rocks	mudstone	lKma	Mudstone, minor sandstone/mudstone, coloured red & green mudstone.		15_undifSed
Late Cretaceous sedimentary rocks	mudstone	lKmm	siltstone- fine sandstone, minor sandstone beds, conglomerate, breccia.		15_undifSed
Late Cretaceous sedimentary rocks	mudstone	lKmw	massive to thick-bedded sandstone		15_undifSed
Basement (Western Province) igneous rocks	orthogneiss	lKn	Foliated hornblende-pyroxene diorite-granodiorite orthogneiss with muscovite; chlorite alteration; biotite absent (or altered)	Late Cretaceous orthogneiss	18_crystalline
Late Cretaceous sedimentary rocks	sandstone	lKo	sandstone with coal seams and minor mudstone and conglomerate	sandstone	15_undifSed
Late Cretaceous sedimentary rocks	conglomerate	lKob	conglomerate	conglomerate	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Allochthonous rocks	sandstone	lKri	Alternating sandstone/mudstone.		15_undifSed
Late Cretaceous sedimentary rocks	sandstone	lKri	Alternating sandstone/mudstone.		15_undifSed
Allochthonous rocks	none	lKri-Kiw	Alternating sandtone and mudstone with minor green and red mudstone and noncalcareous mudstone.		15_undifSed
Allochthonous rocks	breccia	lKrib	Breccia.		15_undifSed
Late Cretaceous sedimentary rocks	sandstone	lKrilKrp	Alternating sandstone and minor mudstone.		15_undifSed
Allochthonous rocks	sandstone	lKris	Sandstone dominated alternating sandstone/mudstone.		15_undifSed
Allochthonous rocks	basalt	lKriv	Basalt.	submarine volcanics	18_crystalline
Allochthonous rocks	mudstone	lKriz	Mudstone, minor sandstone.	mudstone dominated unit	15_undifSed
Allochthonous rocks	sandstone	lKri~	alternating sandstone/mudstone		15_undifSed
Allochthonous rocks	sandstone	lKrp	Sandstone dominated alternating sandstone/mudstone, minor glauconitic sandstone, grit, conglomerate, breccia.		15_undifSed
Late Cretaceous sedimentary rocks	sandstone	lKrp	Sandstone dominated alternating sandstone/mudstone, minor glauconitic sandstone, grit, conglomerate, breccia.		15_undifSed
Late Cretaceous sedimentary rocks	conglomerate	lKscg	cobble to boulder sandy granitic conglomerate with sandstone interbeds	conglomerate	15_undifSed
Late Cretaceous - Paleogene sedimentary rocks	sandstone	lKt	non-marine quartz pebble conglomerate (locally silica-cemented) sandstone siltstone mudstone and coal	quartz sandstone	15_undifSed
Late Cretaceous sedimentary rocks	sandstone	lKw	Conglomerate, sandstone, siltstone and coal measures; basalt and volcanogenic conglomerate	undiff. Wallow Group	15_undifSed
Late Cretaceous sedimentary rocks	sandstone	lKw_	Conglomerate, sandstone, siltstone and coal measures; basalt and volcanogenic conglomerate	undifferentiated late Early and	15_undifSed
Late Cretaceous sedimentary rocks	sandstone	lKwb	Thick-bedded sandstone, alternating sandstone and mudstone, conglomerate and massive sandstone; locally carbonaceous	Bluff Sandstone	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Cretaceous sedimentary rocks	sandstone	lKwb_	Thick-bedded sandstone, alternating sandstone and mudstone, conglomerate and massive sandstone; locally carbonaceous	undifferentiated late Early and	15_undifSed
Late Cretaceous sedimentary rocks	siltstone	lKwb_	Undifferentiated siltstone, sandstone, and conglomerate; includes Whangai and Bluff formations.	Bluff Sandstone and undifferenti	15_undifSed
Late Cretaceous igneous rocks	basalt	lKwg	Dikes, sills, flows and pillows of basalt; volcanogenic conglomerate and breccia	Gridiron Formation	18_crystalline
Late Cretaceous igneous rocks	basalt	lKwg_	Dikes, sills, flows and pillows of basalt; volcanogenic conglomerate and breccia	undifferentiated late Early and	18_crystalline
Late Cretaceous igneous rocks	basalt	lKwl	Pebble conglomerate and coal measures overlain by trachybasalt and trachyandesite flows; volcanic conglomerates, sandstone and l	Lookout Formation	18_crystalline
Late Cretaceous sedimentary rocks	sandstone	lKww	Moderately indurated sandstone, siltstone, minor conglomerate lenses, thin coal measures and lake sediments	Warder Formation	15_undifSed
Late Cretaceous sedimentary rocks	sandstone	lKy	Fine-grained sandstone, commonly sulphurous muddy siltstone, conglomerate, micritic limestone and turbidites.	undifferentiated Seymour Group	15_undifSed
Late Cretaceous sedimentary rocks	sandstone	lKy_	Fine-grained sandstone, commonly sulphurous muddy siltstone, conglomerate, micritic limestone and turbidites.	undifferentiated late Early and	15_undifSed
Late Cretaceous sedimentary rocks	sandstone	lKyp	Glauconitic, bioturbated, fine to medium-grained, graded-bedded sandstone	Paton Formation	15_undifSed
Late Cretaceous sedimentary rocks	chert	lKzm	Strongly indurated, greenish-grey, micritic limestone, calcareous mudstone and black siliceous chert	Mead Hill Formation	15_undifSed
Late Cretaceous sedimentary rocks	chert	lKzm_	Strongly indurated, greenish-grey, micritic limestone, calcareous mudstone and black siliceous chert	undifferentiated late Early and	15_undifSed
Neogene sedimentary rocks	sandstone	lMPbe	Blue-grey; micaceous muddy fine sandstone	Eight Mile Formation	15_undifSed
Neogene sedimentary rocks	sandstone	lMPbo	Blue-grey; micaceous muddy sandstone	OKeefe Formation	15_undifSed
Neogene sedimentary rocks	sandstone	lMPm	Muddy sandstone and carbonaceous sandstone with thin coal seams overlain by Torlesse-derived conglomerate and sandstone	Motunau Group	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Neogene sedimentary rocks	sandstone	lMPm	Silty sandstone with common tuff beds, sandymudstone, minor shelly limestone (Waikura Limestone), local conglomerate.		15_undifSed
Neogene sedimentary rocks	sandstone	lMbf	Local fluviatile sandstone and coal seams		15_undifSed
Neogene sedimentary rocks	gravel	lMc	weathered schist- and quartz-derived gravel sand and mud locally auriferous	auriferous gravel	15_undifSed
Neogene sedimentary rocks	mudstone	lMi	dominantly massive mudstone with minor alternating beds of sandstone and mudstone	undifferentiated late Miocene	15_undifSed
Neogene sedimentary rocks	gravel	lMiPlq	quartz and quartz-greywacke gravel with minor sand and carbonaceous mudstone	quartz gravel	15_undifSed
Neogene sedimentary rocks	gravel	lMiPlq	quartz gravel with minor quartz sand carbonaceous mudstone and lignite	quartz gravel	15_undifSed
Neogene sedimentary rocks	siltstone	lMiPlwr	Interbedded massive siltstone, pebbly mudstone, massive to bedded sandstone, pebbly to bouldery conglomerate; rare shellbeds	siltstone	15_undifSed
Neogene sedimentary rocks	limestone	lMiwg	Bioclastic pebbly limestone, hummocky cross-bedded calcareous sandstone, and shellbeds; basal conglomerate lenses	limestone	15_undifSed
Neogene igneous rocks	basaltic andesite	lMk	Olivine pyroxene basaltic andesite - andesite lava and breccia.	Maungatapu, Ruru, Maungakawa et*	18_crystalline
Neogene sedimentary rocks	conglomerate	lMm	Conglomerate, pebbly sandstone, mudstone and lignite.		15_undifSed
Neogene sedimentary rocks	sandstone	lMm	Interbedded fine to very fine sandstone and mudstone or siltstone, with some channelised conglomerate horizons; massive mudstone		15_undifSed
Neogene sedimentary rocks	sandstone	lMmk	sandstone, minor limestone, mudstone		15_undifSed
Neogene sedimentary rocks	mudstone	lMt	Mudstone, minor sandstone/mudstone, tuff.		15_undifSed
Neogene sedimentary rocks	mudstone	lMt	mudstone, sandstone		15_undifSed
Neogene sedimentary rocks	mudstone	lMt	Thick-bedded sandstone and mudstone, massive mudstone and minor limestone	Undifferentiated Late Miocene	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Neogene sedimentary rocks	sandstone	lMta	Well bedded sandstone and minor mudstone		15_undifSed
Neogene sedimentary rocks	sandstone	lMta	Thick-bedded, calcareous and non-calcareous sandstone and minor mudstone	Ridge-forming Late Miocene sand*	15_undifSed
Neogene sedimentary rocks	sandstone	lMta	Sandstone dominated alternating sandstone/mudstone.		15_undifSed
Neogene sedimentary rocks	sandstone	lMta~	Sandstone dominated alternating sandstone/mudstone.		15_undifSed
Neogene sedimentary rocks	conglomerate	lMtb	Non- to marginal marine conglomerate and cross-bedded sandstone		15_undifSed
Neogene sedimentary rocks	limestone	lMtl	Fossiliferous limestone	Cold seep fauna limestone	15_undifSed
Neogene sedimentary rocks	limestone	lMtp	shelly limestone		15_undifSed
Neogene sedimentary rocks	sandstone	lMtr	Fossiliferous sandstone, minor mudstone, tuff	?Areoma Sandstone	15_undifSed
Neogene sedimentary rocks	sandstone	lMtr	fossiliferous sandstone, minor limestone		15_undifSed
Neogene sedimentary rocks	tuff	lMtv	tuffaceous sandstone/mudstone		15_undifSed
Neogene sedimentary rocks	tuff	lMtv~	tuffaceous sandstone/mudstone		15_undifSed
Neogene sedimentary rocks	sandstone	lMtz	fossiliferous siltstone (muddy sandstone)		15_undifSed
Neogene sedimentary rocks	sandstone	lMtz~	fossiliferous siltstone (muddy sandstone)		15_undifSed
Neogene sedimentary rocks	mudstone	lMt~	Mudstone, minor sandstone, tuff		15_undifSed
Paleogene sedimentary rocks	conglomerate	lOlw	Poorly sorted, sandy, quartz & granite conglomerate/breccia interbedded with carbonaceous sandstone; coalified wood fragments	conglomerate	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Paleogene sedimentary rocks	sandstone	lOlw	Conglomerate and breccia interbedded with cross-bedded sandstone; minor carbonaceous mudstone; rare coal	sandstone	15_undifSed
Paleogene - Neogene sedimentary rocks	limestone	lOlwt	Massive to cross-bedded bioclastic limestone; locally sandy; locally interbedded with calcareous sandstone; sandy at base	limestone	15_undifSed
Paleogene - Neogene sedimentary rocks	limestone	lOlwt	Massive to cross-bedded bioclastic limestone; locally sandy; polygon absorbs minor Point Burn conglomerate & sandstone	limestone	15_undifSed
Paleogene - Neogene sedimentary rocks	limestone	lOw	condensed sequence of bioclastic limestone overlying sandstone and below mustone	limestone	15_undifSed
Paleogene - Neogene sedimentary rocks	limestone	lOw	Graded to cross-bedded sandy limestone	limestone	15_undifSed
Basement (Median Batholith) igneous rocks	gabbro	lPZslg	Metamorphosed gabbro to gabbronorite; minor ultramafics; rare leucotroctolite; localised tonalite along margins	gabbro	18_crystalline
Neogene igneous rocks	basalt	lPlg	Olivine and hypersthene basalt flows	Geraldine basalt	18_crystalline
Neogene lahar deposits	conglomerate	lPlh	Laharic andesitic bouldery conglomerate and coarse sandy gravel; interbedded andesitic tephra	lahar deposits	15_undifSed
Neogene igneous rocks	andesite	lPlha	Eroded often weathered pyroxene andesite lava		18_crystalline
Neogene igneous rocks	rhyolite	lPlm	Flow-banded rhyolite to rhyodacite lava; often as domes or dome complexes, some highly eroded		18_crystalline
Neogene igneous rocks	basalt	lPlt	Olivine and hypersthene basalt in several flows in Timaru area, extending slightly offshore		18_crystalline
Neogene igneous rocks	basalt	lPlt	Olivine and hypersthene basalt flows	Timaru basalt	18_crystalline
Neogene igneous rocks	basalt	lPlt~	Olivine and hypersthene basalt in several flows in Timaru area, extending slightly offshore		18_crystalline
Neogene igneous rocks	basalt	lPlvb	Olivine basalt lava; olivine altered to iddingsite		18_crystalline
Neogene sedimentary rocks	sandstone	lPm	Shallow water conglomerate, sandstone, siltstone and limestone; deeper water mudstone and sandy mudstone	Undifferentiated Pliocene	15_undifSed
Neogene sedimentary rocks	limestone	lPma	Alternating limestone and sandstone with minor conglomerate		15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Neogene sedimentary rocks	limestone	lPmb	Yellow-grey, cross-bedded, barnacle-rich limestone		15_undifSed
Neogene sedimentary rocks	sandstone	lPmc	Calcareous, cross-bedded sandstone and limestone		15_undifSed
Neogene sedimentary rocks	limestone	lPme	Pebbly, barnacle-rich limestone and sandstone		15_undifSed
Neogene sedimentary rocks	limestone	lPmi	Soft, barnacle-rich, creamy-yellow limestone		15_undifSed
Neogene sedimentary rocks	sandstone	lPmj	Alternating sandstone, mudstone and conglomerate		15_undifSed
Neogene sedimentary rocks	sandstone	lPmku	Alternating sequences of sandstone, limestone and mudstone		15_undifSed
Neogene sedimentary rocks	sandstone	lPml	Sandstone, mudstone and minor shell lenses	Undifferentiated lower Late Pli*	15_undifSed
Neogene sedimentary rocks	limestone	lPmm	Pebbly, barnacle-rich limestone, sandstone and siltstone		15_undifSed
Neogene sedimentary rocks	sandstone	lPmn	Alternating sandstone, limestone and mudstone		15_undifSed
Neogene sedimentary rocks	mudstone	lPmo	Alternating sandy mudstone, coarse-grained sandstone and barnacle-rich limestone		15_undifSed
Neogene sedimentary rocks	limestone	lPmp	Pale grey-white, coarse, barnacle-rich limestone with high angle cross-beds		15_undifSed
Neogene sedimentary rocks	limestone	lPmr	Coarse-grained, cross-bedded, yelllow-grey limestone		15_undifSed
Neogene sedimentary rocks	limestone	lPms	Pebbly, barnacle rich limestone and sandstone		15_undifSed
Neogene sedimentary rocks	limestone	lPmt	Sandy coquina limestone	Tahaenui Limestone	15_undifSed
Neogene sedimentary rocks	limestone	lPmt	Yellow-grey, giant foreset-bedded, coarse-grained, barnacle-rich limestone		15_undifSed
Neogene sedimentary rocks	mudstone	lPmu	Locally fossiliferous and tuffaceous massive mudstone, minor sandstone	Undifferentiated upper Late Pli*	15_undifSed
Neogene sedimentary rocks	limestone	lPmx	Alternating sequences of limestone, sandstone, mudstone and conglomerate		15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Neogene sedimentary rocks	limestone	lPmy	Ridge-forming sandstone or limestone horizons mapped from aerial photographs	Undifferentiated limestone or s*	15_undifSed
Neogene sedimentary rocks	mudstone	lPmz	Siltstone, tuffaceous sandstone, limestone		15_undifSed
Neogene igneous rocks	andesite	lPov	Hornblende and pyroxene basaltic andesite to dacite lavas and volcanic breccia		18_crystalline
Neogene igneous rocks	ignimbrite	lPva	Basaltic andesite to dacite ignimbrite		18_crystalline
Neogene igneous rocks	ignimbrite	lPwt	Crystal-rich dacitic welded ignimbrite		18_crystalline
Late Pleistocene - Holocene river deposits	gravel	lQa	Grey to grey brown, slightly weathered; mixtures of gravel/sand/silt/clay river alluvium of Late Quaternary age	Young-medium age alluvium	06_alluvium
Middle Pleistocene - Late Pleistocene river and hill slope deposits	mud	lQa	Predominantly pumiceous sand, silt, mud and clay, with interbedded gravel and peat.	Alluvial and colluvial deposits	06_alluvium
Late Pleistocene - Holocene river deposits	gravel	lQa	gravel/sand/silt/mud river alluvium & lake deposit of undiff Late Quat age; minor peat; lowest terrace capped by ilmenite sand	Late Quaternary alluvium	06_alluvium
Late Pleistocene - Holocene river deposits	gravel	lQa	gravel/sand/silt/mud river alluvium of undiff Late Quaternary age; minor peat.	Late Quaternary alluvium	06_alluvium
Middle Pleistocene - Late Pleistocene river deposits	gravel	lQaf	Moderately weathered undifferentiated poorly sorted gravel, sand, clay and loess	Undifferentiated lQ fan gravel	10_fan
Middle Pleistocene - Late Pleistocene river deposits	gravel	lQaf	Moderately weathered undifferentiated poorly sorted gravel, sand, clay and loess and Q1at pumice alluvium.	Late Quaternary fan gravels and*	10_fan
Middle Pleistocene - Late Pleistocene river deposits	gravel	lQaf	Structureless, bouldery deposits to sandy gravels of variable lithology.	Terrestrial fan deposits	10_fan
Late Pleistocene - Holocene river deposits	gravel	lQaf	Alluvial and colluvial fan deposits consisting of poorly sorted, poorly consolidated gravel, sand and clay	Alluvial fan deposits	10_fan
Late Pleistocene - Holocene river deposits	gravel	lQaf	Angular gravel, sand and silt	alluvial fan	10_fan

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Middle Pleistocene - Late Pleistocene river deposits	gravel	lQaf	partly consolidated poorly sorted sandstone-derived gravel and sand generally loess-covered	alluvial fan	10_fan
Late Pleistocene - Holocene river deposits	gravel	lQag	Moderately weathered, poorly to moderately sorted gravel with minor sand and silt underlying terraces; includes minor fan deposi	alluvial terrace deposits	16_terrace
Middle Pleistocene - Late Pleistocene river deposits	gravel	lQal	Moderately weathered undifferentiated poorly sorted loess-covered alluvial gravel deposits	Undifferentiated lQ alluvium	06_alluvium
Late Pleistocene - Holocene river deposits	mudstone	lQal	Sandstone, mudstone, silicic tephra	defined from QMAP Raukumara	06_alluvium
Middle Pleistocene - Late Pleistocene river deposits	gravel	lQal	Moderately weathered undifferentiated poorly sorted loess-covered alluvial gravel deposits	Undifferentiated late Quaternar*	06_alluvium
Late Pleistocene river deposits	mud	lQal	Poorly consolidated mud, sand, gravel and peat deposits of alluvial, swamp and estuarine origins.	alluvium	06_alluvium
Late Pleistocene - Holocene river deposits	gravel	lQal	Moderately weathered, poorly to moderately sorted gravel with minor sand and silt underlying terraces; includes minor fan deposi	alluvial terrace deposits	16_terrace
Late Pleistocene river deposits	gravel	lQal	partly consolidated well sorted sandstone-derived gravel and sand some peat and mud generally loess-covered	terrace alluvium	16_terrace
Middle Pleistocene - Late Pleistocene river deposits	clay	lQal	Locally derived pumiceous clays, sandy clays and gravels	Alluvial and colluvial deposits	06_alluvium
Late Pleistocene - Holocene river deposits	gravel	lQal	Gravel, sand and silt	alluvial terrace deposits	16_terrace
Late Pleistocene - Holocene river and shoreline deposits	gravel	lQal+lQb	gravel, sand, silt	alluvial and beach deposits	18_crystalline
Late Pleistocene river and estuary deposits	gravel	lQallQae	Alluvial gravel and estuarine sediments.	alluvial and estuarine deposits	06_alluvium

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Pleistocene - Holocene river deposits	gravel	lQap	Moderately weathered, poorly to moderately sorted gravel with minor sand and silt underlying terraces; includes minor fan deposi	alluvial terrace deposits	16_terrace
Late Pleistocene - Holocene swamp deposits	mud	lQas	mud & peat	swamp deposits	05_fluvialEstuarine
Late Pleistocene - Holocene shoreline and swamp deposits	sand	lQb+lQas	sand, peat and mud	sand dune and swamp deposits	09_beachBarDune
Late Pleistocene windblown deposits	sand	lQd	Reddish to dark brown muddy sand and clay-rich sandy paleosols, with rhyolitic ash and pumice lapilli in the upper part.	Dunes and associated facies	11_loess
Late Pleistocene windblown deposits	sand	lQd	Consolidated quartzofeldspathic and mafic-rich sands in fixed dunes, with thin sandy clay beds (paleosols).	Late Pleistocene dunes and assoc	11_loess
Late Pleistocene windblown deposits	sand	lQd	Consolidated quartzofeldspathic and mafic-rich sand in fixed dunes, with thin sandy clay beds (paleosols) and peat.	Undifferentiated lQ dunes	11_loess
Late Pleistocene windblown deposits	sand	lQdk	Massive to cross bedded, well sorted tephric sand, interbedded with minor primary airfall deposits		11_loess
Late Pleistocene windblown deposits	sand	lQdp	Weakly cemented sand in fixed parabolic dunes; minor sand, mud and peat in interdune deposits.	Younger parabolic dunes	11_loess
Late Pleistocene sediment	sand	lQdt	Weakly cemented sand in fixed transverse dune ridges.	Transverse dune ridges	09_beachBarDune
Late Pleistocene - Holocene river deposits	gravel	lQf	locally-derived boulders; gravel etc forming sloping range-front fans and grading to alluvial terraces	fan	10_fan
Late Pleistocene - Holocene river deposits	gravel	lQf	Variably weathered mixtures of gravel/sand/silt forming variably dissected/undissected alluvial fan complexes	Young-medium-age alluvial fan	10_fan
Late Pleistocene - Holocene river deposits	gravel	lQf	Generally unweathered, silty angular gravel & sand forming alluvial fans (surface slope 1-20 deg); some gully dissection	Late Last Glacial or old Q1 fan	10_fan
Late Pleistocene - Holocene river deposits	gravel	lQf	Grey to brown, variable weathered, silty subangular gravel & sand forming alluvial fans(slope 1-20deg); some gully dissection	Young-medium age alluvial fan	10_fan

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Pleistocene - Holocene river deposits	gravel	lQf	Grey to brown, variably weathered, silty subangular gravel & sand w minor peat in alluvial fans(slope 5-20 deg); some gully diss	Young-medium age alluvial fan	10_fan
Late Pleistocene river deposits	sand	lQh	laminated sand and subordinate breccia and gravel; often limonitic	terraces	16_terrace
Late Pleistocene - Holocene lahar deposits	gravel	lQh	Massive to well bedded andesitic gravel and sand, and minor debris deposits	Undifferentiated late Quaternar*	15_undifSed
Late Pleistocene lahar deposits	gravel	lQh	Laharic conglomerate and alluvium	lQ alluvium and lahar deposits	15_undifSed
Middle Pleistocene - Late Pleistocene lahar deposits	gravel	lQh	Massive to well bedded andesitic gravel and sand, and minor debris deposits	Undifferentiated lQ lahars	15_undifSed
Middle Pleistocene - Late Pleistocene lake deposits	silt	lQlk	Lacustrine pumice-bearing sandy or clayey silt	lacustrine sediments	08_lacustrine
Late Pleistocene - Holocene hill slope deposits	debris	lQls	Earthflow deposits containing poorly sorted clasts up to boulder size in a clay matrix	landslide and rockfall detritus	15_undifSed
Middle Pleistocene lake deposits	tephra	lQmb	lacustrine sediments and syn-eruptive water-lain tephra; pumice, silt, sand	Mihi breccia and lake sediments	08_lacustrine
Late Pleistocene igneous rocks	basalt	lQob	basalt scoria and ash		18_crystalline
Late Pleistocene igneous rocks	dacite	lQpd	dacite lava and pumice breccia		18_crystalline
Late Pleistocene igneous rocks	andesite	lQph	Crystal-rich andesite lavas		18_crystalline
Late Pleistocene - Holocene hill slope deposits	gravel	lQs	Boulder field deposit on flat-topped range crests with scree at margins; consists of angular rock debris	Boulder field	15_undifSed
Late Pleistocene - Holocene glacier deposits	gravel	lQt	Poorly consolidated, massive gravel and sand with frequent large boulders	Undifferentiated Late Quaternary	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Pleistocene - Holocene glacier deposits	gravel	lQt	Bouldery diamictons of volcanic clasts set in a sandy muddy matrix	Undifferentiated late Quaternar*	15_undifSed
Late Pleistocene igneous rocks	andesite	lQva	crystal-rich andesite lava flows, tuff, breccia, minor interbedded debris flows, and lenses and dikes of intrusive andesite lav*		18_crystalline
Middle Pleistocene igneous rocks	andesite lava	lQva	Medium grey, phenocryst-rich andesite lava		18_crystalline
Late Pleistocene igneous rocks	breccia	lQvbr	unsorted to poorly sorted, boulder- to cobble-bearing, matrix- to clast-supported hydrothermal explosion breccias; silty	Horohoro, Tahunaatara and undiff	18_crystalline
Late Pleistocene igneous rocks	tuff	lQvmp	ignimbrite, block and ash flow deposits and minor airfall pumice		18_crystalline
Late Pleistocene igneous rocks	rhyolite	lQvmr	plagioclase-orthopyroxene± quartz rhyolite lava domes and carapace breccia	includes main Maroa complex	18_crystalline
Late Pleistocene igneous rocks	rhyolite	lQvor	rhyolite lava		18_crystalline
Late Pleistocene igneous rocks	andesite	lQvp	pyroclastic deposits, volcanic breccia and dark grey basaltic andesite flows with conspicuous olivine phenocrysts		18_crystalline
Late Pleistocene igneous rocks	tephra	lQvtp	rhyolite tephra		18_crystalline
Late Pleistocene igneous rocks	rhyolite	lQvtr	rhyolite lava variably with lesser pumice and breccia as a carapace		18_crystalline
Late Pleistocene igneous rocks	basalt	lQw	tholeiitic basalt with abundant olivine and clinopyroxene phenocrysts forming flows and a scoria cone		18_crystalline
Holocene igneous rocks	andesite	lQwc	andesite to dacite lava, scoria and tuff of the active Central cone	Central cone [White Island]	18_crystalline
Late Pleistocene igneous rocks	andesite	lQwc	andesite to dacite lava, scoria and tuff of the active Central cone	Central cone [White Island]	18_crystalline
Late Pleistocene igneous rocks	andesite	lQwn	andesite to dacite lava, scoria and tuff of the Ngatoro cone	Ngatoro cone [White Island]	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Eastern Province) igneous rocks	andesite	lTJp	porphyritic andesite; rhyolite and trachydacite as flows and shallow intrusions	andesite	18_crystalline
Basement (Median Batholith) igneous rocks	monzodiorite	lTqmd	quartz monzodiorite to tonalite	monzodiorite	18_crystalline
Basement (Eastern Province) sedimentary rocks	sandstone	lTs	Sparsely fossiliferous sheared grey sandstone; siltstone and rare conglomerate	sandstone	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	lTt	sandstone with minor tuff; mudstone; tuff; shellbeds and granitic conglomerate	sandstone	15_undifSed
Basement (Eastern Province) sedimentary rocks	shell beds	lTtw	shellbeds; tuff; sandstone and minor conglomerate	sandstone	15_undifSed
Basement (Eastern Province) igneous rocks	gabbro	lYeThg	predominantly gabbro with olivine gabbro; noritic gabbro; troctolite; and anorthosite with some igneous layering	gabbro	18_crystalline
Basement (Eastern Province) igneous rocks	diorite	lYeThgd	meladiorite on gabbro margins	diorite	18_crystalline
Basement (Median Batholith) igneous rocks	granite	mCaknop	massive to foliated locally megacrystic biotite muscovite garnet granite and granodiorite	granite pluton	18_crystalline
Basement (Median Batholith) igneous rocks	syenogranite	mDdg	Leucocratic, med to very coarse gr, variably foliated, bio±gt±ms syenogranite & alkali feldspar granite; relict feldspar augen	granite	18_crystalline
Basement (Median Batholith) metamorphic rocks	granodiorite	mDsrg	Coarse grained, strongly foliated to gneissic bio±gt±ms granite, granodiorite & minor tonalite; mylonitic along shear zones	granodiorite	18_crystalline
Basement (Median Batholith) igneous rocks	granite	mJdepp	biotite granite and leucogranite with minor granodiorite	granite	18_crystalline
Basement (Eastern Province) sedimentary rocks	sandstone	mJf	indurated fossiliferous massive to thin bedded marine sediments with tuff and plant beds closely jointed zeolitised	sandstone mudstone	15_undifSed

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Basement (Eastern Province) sedimentary rocks	sandstone	mJf	sandstone and interbedded mudstone with minor shellbeds; and conglomerate and coal	sandstone	15_undifSed
Basement (Eastern Province) sedimentary rocks	conglomerate	mJfc	conglomerate with sandstone interbeds	conglomerate	15_undifSed
Basement (Eastern Province) sedimentary rocks	mudstone	mJfm	zeolitised mudstone with minor sandstone and siltstone	mudstone	15_undifSed
Basement (Eastern Province) sedimentary rocks	conglomerate	mJfmc	coarse conglomerate with thin sandstone beds	conglomerate	15_undifSed
Basement (Median Batholith) igneous rocks	syenogranite	mJhig	Leucocratic, pink-white, coarse grained, massive, equigranular, biotite±gt syenogranite and minor monzogranite	granite	18_crystalline
Basement (Median Batholith) igneous rocks	granite	mJlmg	Leucocratic, coarse grained, massive, biotite granite; minor granodiorite	granite	18_crystalline
Basement (Eastern Province) sedimentary rocks	conglomerate	mJm	indurated well sorted unfossiliferous nonmarine sediments with plant beds	conglomerate sandstone	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	mJm	sandstone and conglomerate; rarely carbonaceous; with minor mudstone	sandstone	15_undifSed
Basement (Eastern Province) sedimentary rocks	conglomerate	mJmc	conglomerate with subordinate grit and sandstone	conglomerate	15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	mJr	Well-bedded fine sandstone and siltstone, with thick sandstone and siltstone and minor conglomerate near base, and coarse tuffac		15_undifSed
Basement (Eastern Province) sedimentary rocks	sandstone	mJr	Carbonaceous sandstone with interbedded siltstone and conglomerate; some tuff, shale and thin coal seams.		15_undifSed
Basement (Median Batholith) igneous rocks	diorite	mJrakd	Diorite and quartz monozodiorite, and heterogenous gabbro, anothosite and microdiorite	diorite pluton	18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Basement (Median Batholith) igneous rocks	granite	mJswap	massive medium locally megacrystic biotite titanite granodiorite and granite; locally foliated	granite pluton	18_crystalline
Neogene sedimentary rocks	calcareous mudstone	mMbs	Grey calcareous mudstone	Stillwater Mudstone	15_undifSed
Neogene sedimentary rocks	mudstone	mMi	sandy mudstone with mudstone and sandstone interbeds	undifferentiated middle Miocene	15_undifSed
Neogene sedimentary rocks	sandstone	mMit	Mudstone, overlain by graded sandstone-mudstone beds, and conglomerate interbedded with sandstone; minor basaltic flow rocks	sandstone	15_undifSed
Neogene sedimentary rocks	sandstone	mMit	Mudstone, overlain by graded sandstone-mudstone beds, and conglomerate interbedded with sandstone	sandstone	15_undifSed
Neogene sedimentary rocks	sandstone	mMiwb	graded sandstone and mudstone	sandstone	15_undifSed
Neogene sedimentary rocks	sandstone	mMiwd	graded sandstone and mudstone	sandstone	15_undifSed
Neogene sedimentary rocks	conglomerate	mMiwm	conglomerate and pebbly mudstone in slump sheets with graded sandstone and mudstone	conglomerate	15_undifSed
Neogene sedimentary rocks	conglomerate	mMiwm	Conglomerate (often graded) and pebbly mudstone, sandy conglomerate, and interbedded sandstone and mudstone	conglomerate	15_undifSed
Neogene sedimentary rocks	lignite	mMl	lignite minor sandstone and tuff	lignite	15_undifSed
Neogene sedimentary rocks	volcanic sandstone	mMm	Well bedded, graded volcanic sandstone and mudstone.		17_volcanic
Neogene sedimentary rocks	siltstone	mMm	Lacustrine clay, silt and sand with lignite seams; basal fluvial quartz sand and conglomerate		05_fluvialEstuarine
Neogene sedimentary rocks	sand	mMm	Quartz sand & gravel with lignite seams (Dunstan), overlain by interbedded clay, silt & minor sst (Bannockburn); sarsen stones	quartz sands	15_undifSed
Neogene sedimentary rocks	sand	mMm	Quartz sand & gravel with lignite seams (Dunstan), overlain by clay, silt, minor sst & oil shale (Bannockburn); sarsen stones	quartz sands	15_undifSed
Neogene sedimentary rocks	quartzite	mMmc	silica-cemented fluvial quartz sand and conglomerate generally at base of Manuherikia Group		05_fluvialEstuarine

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Neogene sedimentary rocks	quartzite	mMmc	silica-cemented quartz sandstone and conglomerate as sarsen stones	sarsen stones	15_undifSed
Neogene sedimentary rocks	quartzite	mMmc	Silica-cemented basal quartz sand and gravel forming lag deposits of sarsen stones	sarsens	15_undifSed
Neogene sedimentary rocks	sandstone	mMo	massive argillaceous, fine- to medium-grained sandstone with some mudstone and conglomerate; basal sandy limestone locally (Mang		15_undifSed
Neogene sedimentary rocks	sandstone	mMo	Massive argillaceous, fine- to medium-grained sandstone; mudstone and conglomerate; basal sandy limestone locally (Mangarara F.)	Mangarara and Otunui formations	15_undifSed
Neogene sedimentary rocks	sandstone	mMo	Massive argillaceous, fine- to medium-grained sandstone with some mudstone and conglomerate; basal sandy limestone locally.		15_undifSed
Neogene sedimentary rocks	sandstone	mMo	Pebbly sandstone, fine-grained sandstone, sandy siltstone and limestone		15_undifSed
Neogene sedimentary rocks	conglomerate	mMru	Conglomerate composed largely of schist clasts	Upper Rappahannock Group	15_undifSed
Neogene sedimentary rocks	mudstone	mMt	Mudstone, minor sandstone.		15_undifSed
Neogene sedimentary rocks	sandstone	mMt	Bioclastic sandstone and sandy limestone with volcaniclastic sandstone layers.		15_undifSed
Neogene sedimentary rocks	sandstone	mMt	Thick graded beds of conglomerate & pebbly sandstone, grey feldspathic sandstone and calcaerous mudstone.	Tititira Formation	15_undifSed
Neogene sedimentary rocks	sandstone	mMt	Alternating sandstone and mudstone, massive mudstone and minor limestone	Undifferentiated Middle Miocene	15_undifSed
Neogene sedimentary rocks	sandstone	mMt	Graded sandstone-mudstone beds, overlying mudstone, and grading up into conglomerate with interbeds of sandstone	sandstone	15_undifSed
Neogene sedimentary rocks	mudstone	mMt	mudstone, minor sandstone.		15_undifSed
Neogene sedimentary rocks	sandstone	mMt	Thick graded beds of conglomerate & pebbly sandstone, grey feldspathic sandstone and calcareous mudstone.	Tititira Formation	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Neogene sedimentary rocks	mudstone	mMt	Mudstone, minor sandstone, tuff beds		15_undifSed
Neogene sedimentary rocks	sandstone	mMta	Alternating sandstone/mudstone.		15_undifSed
Neogene sedimentary rocks	limestone	mMth	limestone, sandstone, mudstone, conglomerate	shallow marine sediments	15_undifSed
Neogene sedimentary rocks	limestone	mMtl	Sandy to pebbly pinkish pebbly limestone with barnacle debris	Middle Miocene limestone	15_undifSed
Neogene sedimentary rocks	sandstone	mMtu	Alternating sandstone/mudstone.	Tunanui Formation	15_undifSed
Neogene sedimentary rocks	sandstone	mMtu	alternating sandstone/mudstone.		15_undifSed
Middle Pleistocene river deposits	gravel	mQa	Moderately to highly weathered brown gravel in highly weathered sandy matrix, overlain by up to 3 loesses; clasts of greywacke;	alluvium	06_alluvium
Middle Pleistocene river deposits	gravel	mQa	Consolidated, weakly weathered, muddy to sandy gravel outwash terrace remnants; contains well-rounded cobbles & boulders	Medium-old outwash	12_outwash
Middle Pleistocene river deposits	gravel	mQa	weathered gravel and sand in dissected terrace remnants several metres of loess locally eroded	terrace alluvium	16_terrace
Middle Pleistocene river deposits	gravel	mQa	Grey brown to yellow brown, slightly-highly weathered gravel/sand/silt/clay mixtures; forms dissected river terraces;loess cover	Old river alluvium/outwash	12_outwash
Middle Pleistocene river deposits	gravel	mQa	Slightly - moderately weathered mixtures of gravel sand silt and clay forming dissected river terraces/plateaux	Old river alluvium/outwash	12_outwash
Middle Pleistocene river deposits	gravel	mQa_ta	Slightly - moderately weathered mixtures of gravel/sand/silt/clay in dissected river terrace remnants	Medium-old glacial outwash	12_outwash
Middle Pleistocene river deposits	gravel	mQa_we	Slightly weathered mixtures of gravel/sand/silt/clay in dissected river terraces	Medium-age glacial outwash	12_outwash
Middle Pleistocene river deposits	gravel	mQaf	weathered sandy gravel in high fans	alluvial fans	10_fan

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Middle Pleistocene river deposits	gravel	mQag	Poorly to moderately sorted gravel with minor sand and silt underlying terraces; includes minor fan deposits and loess	alluvial terrace deposits	16_terrace
Middle Pleistocene river and lake deposits	mudstone	mQah	alternating calcareous and carbonaceous lake beds	lake deposits	10_fan
Middle Pleistocene lahar deposits	conglomerate	mQaka	Andesitic lahar deposits	lahar deposits	15_undifSed
Middle Pleistocene river deposits	gravel	mQal	undifferentiated middle Pleistocene alluvial gravels	Middle Quaternary alluvial terr*	06_alluvium
Middle Pleistocene river deposits	gravel	mQal	weathered greywacke-schist gravel in high terrace remnants in the Clutha catchment	terrace gravels	16_terrace
Middle Pleistocene river deposits	gravel	mQal	undifferentiated middle Pleistocene alluvial gravels	alluvial deposits	06_alluvium
Middle Pleistocene river and lake deposits	gravel	mQal	Weathered; poorly sorted loess-covered fan gravel; alluvial gravel and lacustrine silt deposits; including Ahiaruhe Formation		10_fan
Middle Pleistocene river deposits	gravel	mQal	weathered sandy greywacke (quartz) gravel in high terraces; includes dune sand	alluvial terraces	16_terrace
Middle Pleistocene river deposits	gravel	mQal	weathered sandy greywacke gravel overlain by loess in very high terrace remnants	alluvial terraces	16_terrace
Middle Pleistocene river deposits	gravel	mQal	Poorly to moderately sorted gravel with minor sand and silt underlying terraces; includes minor fan deposits and loess	alluvial terrace deposits	16_terrace
Early Pleistocene - Middle Pleistocene river deposits	gravel	mQam	Poorly to moderately sorted gravel with minor sand and silt underlying terraces; includes minor fan deposits and loess	alluvial terrace deposits (Auck*	16_terrace
Early Pleistocene - Middle Pleistocene river deposits	gravel	mQam	Poorly to moderately sorted gravel with minor sand and silt underlying terraces; includes minor fan deposits and loess	alluvial terrace deposits	16_terrace
Middle Pleistocene river deposits	gravel	mQao	weathered bouldery to sandy outwash gravel on Paddock Hill	outwash gravel	12_outwash
Middle Pleistocene river deposits	gravel	mQap	Poorly to moderately sorted gravel with minor sand and silt underlying terraces; includes minor fan deposits and loess	alluvial terrace deposits	16_terrace

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Middle Pleistocene shoreline deposits	sand	mQb	Weathered sand and gravel beneath coastal terraces more than 150 m above sea level	Old raised marine terrace	16_terrace
Middle Pleistocene shoreline deposits	sand	mQb	Weathered well rounded beach pebbles in fine sand matrix with fine sand lenses; overlain by several loesses; >30 m ASL at Goodwo	raised beaches	09_beachBarDune
Middle Pleistocene shoreline deposits	gravel	mQb	undifferentiated middle Pleistocene marine gravels and sand	marine bench deposits	15_undifSed
Middle Pleistocene shoreline deposits	gravel	mQb	Undifferentiated Middle Quaternary marine and marginal marine gravel; sand and silt	Marine deposits	15_undifSed
Middle Pleistocene shoreline deposits	sand	mQb_ch	Marine gravel and sand	Cement Hill marine terrace	16_terrace
Middle Pleistocene shoreline deposits	silt	mQb_pc	Varved silt; marine sand and mud	Pug Creek marine sediment	15_undifSed
Middle Pleistocene shoreline deposits	sand	mQb_sc	Marine gravel and sand	Sandfly Creek marine terrace	16_terrace
Middle Pleistocene windblown deposits	sand	mQd	Dune deposits of windblown, yellow-brown, river sand	Old dunes	11_loess
Middle Pleistocene windblown deposits	silt	mQe	Multiple yellow and brown loess layers; locally interbedded paleosols; rarely peat	Mid-Late Quaternary loess	11_loess
Middle Pleistocene windblown deposits	loess	mQe	Yellow-brown windblown silt deposits, locally with fine sand or clay; >3m thick & commonly in mulitple layers; thicker downslope	Loess	11_loess
Middle Pleistocene windblown deposits	loess	mQe	Multiple yellow and brown loess layers with interbedded paleosols and peat; may span much of mid and late Quaternary in age	loess	11_loess
Middle Pleistocene river deposits	gravel	mQf	Moderately to highly weathered piedmont fan gravels with variable loess cover	fans	10_fan
Middle Pleistocene river deposits	gravel	mQf	Brown, weathered, mod to poorly sorted silty subangular gravel & sand fan alluvium in dissected fan terraces (slope 1-20deg)	Old alluvial fan	10_fan
Middle Pleistocene river deposits	gravel	mQf	Slightly - moderately weathered mixtures of gravel sand silt and clay forming very dissected alluvial fans	Old alluvial fan	10_fan
Neogene igneous rocks	tephra	mQh	Strongly weathered, clay-textured, multiple rhyolitic tephra deposits and associated paleosols.		18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Middle Pleistocene lake deposits	silt	mQhlk	Silty, commonly diatomaceous, millimetre-laminated lacustrine sediments; dominated by pumice, lava fragments, crystals	type 'Huka Group' lake sediments	08_lacustrine
Middle Pleistocene igneous rocks	andesite	mQka	Andesite lava		18_crystalline
Middle Pleistocene lake deposits	silt	mQlk	Silty, commonly diatomaceous, millimetre-laminated lacustrine sediments; dominated by pumice, lava fragments, crystals	(undifferentiated)	08_lacustrine
Middle Pleistocene hill slope deposits	debris	mQls	Earthflow deposits containing poorly sorted clasts up to boulder size in a clay matrix	landslide and rockfall detritus	15_undifSed
Early Pleistocene - Middle Pleistocene river deposits	sand	mQm	Pumiceous, alluvial gravel, sand and mud with peat. Estuarine silt and mud, and minor beach sand interbedded with ignimbrite and		06_alluvium
Middle Pleistocene - Late Pleistocene igneous rocks	andesite	mQpk	Andesite lava		18_crystalline
Early Pleistocene - Middle Pleistocene sedimentary rocks	conglomerate	mQs	Sandstone, siltstone, bioclastic limestone and conglomerate, including OIS 15-9 marine terrace deposits		15_undifSed
Early Pleistocene - Middle Pleistocene sedimentary rocks	sandstone	mQs	Sandstone, siltstone, bioclastic limestone and conglomerate, including OIS 15-9 marine terrace deposits		15_undifSed
Middle Pleistocene igneous rocks	andesite	mQsv	Porphyritic plagioclase-hornblende andesite flows, agglomerate and tuff, with minor dikes; rare intercalated lignite	andesite	18_crystalline
Middle Pleistocene glacier deposits	gravel	mQt	Yellow-brown, slightly to highly weathered bouldery till; mixtures of gravel/sand/silt/clay in dissected moraine remnants	Old till	14_moraineTill
Middle Pleistocene glacier deposits	gravel	mQt	Slightly to highly weathered bouldery till; variable mixtures of gravel/sand/silt/clay in dissected moraine remnants	Old till	14_moraineTill
Middle Pleistocene glacier deposits	till	mQt	Semi-consolidated, slightly weathered clayey bouldery till and gravel	Medium-old till	14_moraineTill
Middle Pleistocene glacier deposits	till	mQt	Semi-consolidated, slightly weathered clayey bouldery till and sandy outwash gravel	Medium-old till	14_moraineTill

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Middle Pleistocene glacier deposits	gravel	mQt_co	Slightly to moderately weathered bouldery till; variable mixtures of gravel/sand/silt/clay in dissected moraine remnants	Medium-old till	14_moraineTill
Middle Pleistocene glacier deposits	gravel	mQt_ta	Slightly to moderately weathered bouldery till; variable mixtures of gravel/sand/silt/clay in dissected moraine remnants	Medium-old till	14_moraineTill
Middle Pleistocene glacier deposits	gravel	mQt_we	Slightly weathered bouldery till; variable mixtures of gravel/sand/silt/clay in mid-level moraines	Medium-age till	14_moraineTill
Middle Pleistocene igneous rocks	andesite	mQta	Silicic andesite lavas		18_crystalline
Middle Pleistocene igneous rocks	andesite	mQtg	Hornblende-bearing andesite with minor basaltic andesite		18_crystalline
Middle Pleistocene - Late Pleistocene igneous rocks	andesite	mQti	Andesite, basaltic andesite, pyroclastic deposits, breccia, tuff; includes "Pounamu Tuff breccia" of Nairn 1997		18_crystalline
Middle Pleistocene - Late Pleistocene igneous rocks	andesite	mQtk	Flows of plagioclase-pyroxene andesite		18_crystalline
Middle Pleistocene sedimentary rocks	sandstone	mQu	Well-bedded ash-bearing marine sands	also Unit A	15_undifSed
Middle Pleistocene sedimentary rocks	mudstone	mQu	Marine mudstone and sandstone, primary volcanic fall deposits, alluvium; in east weathered greywacke gravels, paleosols	undifferentiated Early Quaternar	15_undifSed
Middle Pleistocene sedimentary rocks	mudstone	mQu	Marine mudstone and sandstone, primary volcanic fall deposits, alluvium; in east weathered greywacke gravels, paleosols		15_undifSed
Middle Pleistocene igneous rocks	basalt	mQvba	Basalt, scoria and ash		18_crystalline
Middle Pleistocene igneous rocks	basalt	mQvbb	Basalt, scoria and ash		18_crystalline
Middle Pleistocene igneous rocks	basalt	mQvbj	Basalt, scoria and ash		18_crystalline
Middle Pleistocene igneous rocks	basalt	mQvbk	Basalt, scoria and ash		18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Middle Pleistocene igneous rocks	basalt	mQvbm	Basalt, scoria and ash		18_crystalline
Middle Pleistocene igneous rocks	basalt	mQvbo	Basalt, scoria and ash		18_crystalline
Middle Pleistocene igneous rocks	basalt	mQvbp	Basalt, scoria and ash		18_crystalline
Middle Pleistocene igneous rocks	basalt	mQvbt	Basalt, scoria and ash		18_crystalline
Middle Pleistocene igneous rocks	dacite	mQvd	Dacite, pumice, breccia	Includes four peaks	18_crystalline
Middle Pleistocene igneous rocks	andesite lava	mQvk	Deeply weathered, often silicifed andesite lava		18_crystalline
Middle Pleistocene igneous rocks	andesite	mQvk	Medium-K, pyroxene to hornblende andesite		18_crystalline
Middle Pleistocene igneous rocks	andesite lava	mQvm	Pyroxene and hornblende andesite lava flows		18_crystalline
Middle Pleistocene igneous rocks	tephra	mQvop	Tephra including flow and fall deposits, some consolidated as tuff		18_crystalline
Middle Pleistocene igneous rocks	rhyolite	mQvor	rhyolite lava variably with lesser pumice and breccia as a carapace		18_crystalline
Middle Pleistocene igneous rocks	andesite lava	mQvp	Hornblende and augite andesite lava and breccia		18_crystalline
Middle Pleistocene igneous rocks	tephra	mQvp	Tephra including flow and fall deposits, some consolidated as tuff		18_crystalline
Middle Pleistocene igneous rocks	andesite lava	mQvt	Medium to pale grey, phenocryst-rich andesite lava and minor block-and-ash-fall deposits		18_crystalline
Middle Pleistocene igneous rocks	andesite	mQvt	Pale-grey, crystal rich andesite flows, dikes, plugs and tuffs		18_crystalline
Middle Pleistocene igneous rocks	rhyolite	mQvtr	Hypersthene-hornblende rhyolite	Undifferentiated Taupo lavas	18_crystalline
Middle Pleistocene igneous rocks	rhyolite	mQvtr	rhyolite lava variably with lesser pumice and breccia as a carapace		18_crystalline
Middle Pleistocene igneous rocks	rhyolite	mQvur	rhyolite lava variably with lesser pumice and breccia as a carapace		18_crystalline

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Middle Pleistocene igneous rocks	tephra	mQvwp	tephra, pumice and dome carapace breccia		18_crystalline
Middle Pleistocene igneous rocks	tephra	mQvwp	tephra, pumice and dome carapace breccia	[Ongaroto Group?]	18_crystalline
Middle Pleistocene igneous rocks	rhyolite	mQvwr	crystal-poor plagioclase orthopyroxene rhyolite lavas; some contain hornblende, two contain biotite	[Ongaroto Group?]	18_crystalline
Middle Pleistocene igneous rocks	rhyolite	mQvwr	crystal-poor plagioclase orthopyroxene rhyolite lavas; some contain hornblende, two contain biotite		18_crystalline
Middle Pleistocene igneous rocks	basaltic andesite	mQwh	Basaltic andesite to dacite lava domes	Whale Island volcanics	18_crystalline
Basement (Eastern Province) sedimentary rocks	sandstone	mTk	folded sandstone with subordinate mudstone and minor tuff and conglomerate	sandstone	15_undifSed
Basement (Eastern Province) igneous rocks	diorite	mTmpi	porphyritic hornblende microdiorite and andesite	andesite	18_crystalline
Basement (Eastern Province) sedimentary rocks	sandstone	mTu	sandstone with shellbeds and granitic conglomerate	sandstone	15_undifSed
Late Cretaceous - Neogene melange	melange	mel	undifferentiated Whangai, Wanstead and Weber formations and Early Miocene in a sheared matrix	Undifferentiated Late Cretaceou*	15_undifSed
Allochthonous rocks	melange	mel	melange	melange	15_undifSed
Late Cretaceous - Neogene melange	melange	mel	undifferentiated Whangai Formation, Wanstead Formation and Weber Formation in a sheared matrix		15_undifSed
Late Cretaceous - Neogene melange	melange	mel	melange	melange	15_undifSed
Late Cretaceous - Neogene melange	melange	mel~	melange	melange	15_undifSed
Middle Pleistocene - Late Pleistocene glacier deposits	till	mlQt	Variably weathered, generally bouldery angular gravel with minor sand (=till) in cirque or upper valley moraines	Young to medium age till	14_moraineTill
Middle Pleistocene - Late Pleistocene glacier deposits	till	mlQt	Poorly exposed, consolidated, slightly weathered, muddy to bouldery till with preserved lateral moraine ridge topography	Undifferentiated till	14_moraineTill

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Pleistocene - Holocene river deposits	gravel	uQa	weathered gravel/sand/silt/clay mixtures; forms high level remnant flood plain/outwash deposits	Very old river alluvium/outwash	12_outwash
Pleistocene - Holocene river deposits	silt	uQaf	alluvial fans; scree and slopewash overlying pediment surfaces	pediment surfaces	06_alluvium
Pleistocene - Holocene river deposits	gravel	uQaf	Undifferentiated older alluvial fans		06_alluvium
Pleistocene - Holocene river deposits	gravel	uQaf	Undifferentiated poorly sorted gravels forming alluvial fans and colluvial deposits	alluvial fan deposits	10_fan
Late Pleistocene - Holocene river deposits	silt	uQaf	alluvial fans; scree and slopewash overlying pediment surfaces	pediment surfaces	06_alluvium
Late Pleistocene - Holocene river deposits	gravel	uQaf	undifferentiated fresh to deeply weathered locally derived clayey to sandy gravel in alluvial fans	alluvial fans	10_fan
Pleistocene - Holocene river deposits	gravel	uQaf	Undifferentiated poorly sorted steep fan gravel deposits	Fan gravel	10_fan
Pleistocene - Holocene river deposits	gravel	uQaf	weathered unsorted, undifferentiated fan gravel	alluvial fans	10_fan
Pleistocene - Holocene river deposits	sand	uQaf	gravel and sand in alluvial fans and colluvial slope aprons	alluvial fan	10_fan
Pleistocene - Holocene river deposits	gravel	uQaf	undifferentiated fresh to deeply weathered locally derived clayey to sandy gravel in alluvial fans	alluvial fans	10_fan
Pleistocene - Holocene river deposits	gravel	uQaf	Variably weathered, unsorted, locally derived, angular to rounded, sandy gravel in relatively older alluvial fans	alluvial fans	10_fan
Pleistocene - Holocene river deposits	gravel	uQaf	Weathered undifferentiated poorly sorted gravel, sand, clay and loess	Undifferentiated Quaternary fan deposits	10_fan
Late Pleistocene - Holocene river deposits	gravel	uQaf	Weathered undifferentiated poorly sorted gravel, sand, clay and loess	Undifferentiated Quaternary fan*	10_fan
Pleistocene - Holocene river deposits	gravel	uQaf	Variably weathered, unsorted, locally derived, angular to rounded, sandy gravel in undifferentiated alluvial fans	alluvial fans	10_fan

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Pleistocene - Holocene river deposits	gravel	uQal	weathered unsorted, undifferentiated alluvial gravel	undifferentiated alluvium	06_alluvium
Pleistocene - Holocene river deposits	gravel	uQal	Undifferentiated weathered; poorly sorted loess-covered alluvial gravel deposits	Alluvial deposits	06_alluvium
Pleistocene - Holocene river deposits	gravel	uQal	Weathered undifferentiated poorly sorted loess-covered alluvial gravel deposits	Undifferentiated Quaternary alluvium	06_alluvium
Late Pleistocene - Holocene river deposits	gravel	uQal	sandy gravel in high terrace remnants	alluvium	06_alluvium
Pleistocene - Holocene river deposits	gravel	uQal	Undifferentiated weathered; poorly sorted loess-covered alluvial gravel deposits	alluvial deposits	06_alluvium
Late Pleistocene - Holocene river deposits	gravel	uQal	Weathered undifferentiated poorly sorted loess-covered alluvial gravel deposits	Undifferentiated Quaternary all*	06_alluvium
Pleistocene - Holocene river deposits	gravel	uQal	Undifferentiated alluvium	alluvial deposits	06_alluvium
Pleistocene - Holocene river deposits	gravel	uQal	Undifferentiated and variably weathered sandy gravel in outwash terrace remnants and valley heads	alluvium	06_alluvium
Pleistocene - Holocene shoreline deposits	gravel	uQb	Undifferentiated beach deposits generally consisting of marine sand on raised terraces	beach deposits	09_beachBarDune
Pleistocene - Holocene shoreline deposits	sand	uQb	Slightly weathered sand and gravel underlying raised coastal terraces	beach deposits undifferentiated	09_beachBarDune
Pleistocene - Holocene shoreline deposits	sand	uQb	Undifferentiated marine sand and gravel often weathered		15_undifSed
Pleistocene - Holocene shoreline deposits	gravel	uQb	Undifferentiated beach deposits generally consisting of marine sand on highest raised terraces	Undifferentiated Quaternary beach deposits	09_beachBarDune
Middle Pleistocene - Late Pleistocene lahar deposits	gravel	uQh	Poorly sorted boulders, gravel and sand	Undifferentiated Quaternary lah*	15_undifSed
Middle Pleistocene - Late Pleistocene lahar deposits	gravel	uQh	Massive to well bedded gravel and sand, and minor debris deposits	Undifferentiated Quaternary lahar deposits	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Pleistocene - Holocene lake deposits	silt	uQk	Variable mixtures of bedded and locally contorted silt/sand/gravel/clay at margins of middle Rakaia valley	undifferentiated lake deposit	08_lacustrine
Pleistocene - Holocene hill slope deposits	breccia	uQl	Landslide deposits ranging from coherent shattered masses of rock to unsorted fragments in a fine-grained matrix	landslide deposits	15_undifSed
Pleistocene - Holocene hill slope deposits	gravel	uQl	Undifferentiated landslide debris		15_undifSed
Pleistocene - Holocene hill slope deposits	breccia	uQl	Chaotic unsorted debris in landslides and earthflows; mixture of Tertiary-derived debris	Undifferentiated landslide	15_undifSed
Pleistocene - Holocene hill slope deposits	breccia	uQl	unsorted bouldery gravel to large displaced blocks in major landslides and slope failures	landslides	15_undifSed
Pleistocene - Holocene hill slope deposits	breccia	uQl	ranges from shattered but relatively coherent rockslides to chaotic unsorted rock or soil debris in slumps & debri flow deposits	landslide undifferentiated	15_undifSed
Pleistocene - Holocene hill slope deposits	breccia	uQl	Debris of variable content; may include large rock/soil blocks/fragmental debris/plastic silt-clay; associated with landslides	landslide	15_undifSed
Pleistocene - Holocene hill slope deposits	gravel	uQl	landslide debris	undifferentiated landslides	15_undifSed
Pleistocene - Holocene hill slope deposits	breccia	uQl	Landslide deposits ranging from coherent shattered masses of rock to unsorted fragments in a fine-grained matrix	Landslide deposits	15_undifSed
Late Pleistocene - Holocene hill slope deposits	unknown	uQl	Unconsolidated to poorly consolidated landslide and rockfall deposits of mixed lithologies.	Landslide debris	15_undifSed
Pleistocene - Holocene hill slope deposits	boulders	uQl	Undifferentiated earthflow deposits containing poorly sorted clasts up to boulders size in a clay matrix	landslide deposits	15_undifSed
Pleistocene - Holocene hill slope deposits	breccia	uQl	Chaotic unsorted debris in landslides varying from rock falls to debris flows	Undifferentiated landslide	15_undifSed
Late Pleistocene - Holocene hill slope deposits	debris	uQls	Landslide deposits ranging from coherent shattered masses of rock to unsorted fragments in a fine-grained matrix	Landslide and rockfall detritus	15_undifSed

SIMPLE_NAME	MAIN_ROCK	UNIT_CODE	DESCRIPTION	MAP_UNIT	groupID_AhdiAK
Late Pleistocene hill slope deposits	debris	uQls	Landslide deposits ranging from coherent shattered masses of rock to unsorted fragments in a fine-grained matrix	Landslide and rockfall detritus	15_undifSed
Pleistocene - Holocene hill slope deposits	gravel	uQs	Variably weathered inactive scree/colluvium on slopes; boulder fields on flat-topped range-crests; may merge with tills/ fans	undifferentiated slope deposit	14_moraineTill
Pleistocene - Holocene glacier deposits	till	uQt	undifferentiated unsorted angular to rounded sandy to bouldery till	moraines	14_moraineTill
Pleistocene - Holocene glacier deposits	gravel	uQt	Undifferentiated till, very poorly sorted	glacial deposits	14_moraineTill
Late Pleistocene glacier deposits	gravel	uQt	Weathered, poorly consolidated, massive gravel, sand and mud with frequent large boulders	Undifferentiated Quaternary till	15_undifSed
Middle Pleistocene - Late Pleistocene glacier deposits	gravel	uQt	Poorly sorted boulder sized angular to subangular clasts in stiff clay matrix	Undifferentiated Quaternary til*	15_undifSed
Pleistocene - Holocene glacier deposits	till	uQt	Undifferentiated till consisting of variably weathered, generally bouldery angular gravel with minor sand in cirque moraines	till	14_moraineTill
Pleistocene - Holocene glacier deposits	till	uQt	variably weathered bouldery till; poorly sorted mixtures of gravel/sand/silt/clay; moraine morphology poorly preserved	till undifferentiated	14_moraineTill
water		water	lakes; rivers; lagoons; sea		00_WATER
water		water			00_WATER

Appendix C

Bayesian updating

The implementation in Gelman et al. (2014, pp. 67-69) is as follows. After transformation to log space, the conditional posterior distribution of μ given σ is normal and centered on

$$\mu_n = \frac{\kappa_0 \mu_0 + n\bar{y}}{\kappa_0 + n} \tag{C.1}$$

where n is the length of the data vector, μ_n is the median of the distribution for the posterior median, $\bar{y}$ is mean of the data vector, and κ_0 represents the number of observations in the prior. σ is updated assuming a scaled inverse-chi-squared (Inv-χ^2) marginal posterior density parameterized as

$$\sigma_n^2 | y \sim \text{Inv-}\chi^2 \left(\nu_n, \sigma_n^2\right). \tag{C.2}$$

ν_0 and ν_n respectively represent the prior and posterior degrees of freedom for the Inv-χ^2 distribution, and we assume $\kappa = \nu$ so that $\kappa_n = \kappa_0 + n = \nu_n = \nu_0 + n$ become the new values of κ and ν. (These values become the new value of $\kappa_0 = \nu_0$ for repeated applications of Bayesian updating.) The quantity

$$\nu_n \sigma_n^2 = \nu_0 \sigma_0^2 + (n-1)\, s^2 + \frac{\kappa_0 n}{\kappa_0 + n} \left(\bar{y} - \mu_0\right)^2 \tag{C.3}$$

is the posterior sum of squares, “which combines the prior sum of squares, the sample sum of squares, and the additional uncertainty conveyed by the difference between the sample mean and the prior mean." (Gelman et al., 2014). Here s^2 is the variance of the data vector. Dividing both sides of Equation C.3 by ν_n gives the posterior variance, which in turn completes the parameterization of the marginal posterior distribution for σ^2 (Equation C.2). For our application the posterior variance is simply chosen as the maximum likelihood or expected value for the scaled inverse-chi-squared distribution, which is $\frac{\nu_n}{\nu_n - 2}\sigma_n^2$ for $\nu > 2$.

Appendix D

Solving for V_S: Roots, signs

The question arises how to approach handling records with negative values of $\frac{\dot{U}_R}{\dot{U}_Z}$ in the context of automated processing. For the limiting case as $\frac{\dot{U}_R}{\dot{U}_Z}$ approaches zero, which would occur where the basement velocity contrast is extremely sharp (hence, soils are very soft) and/or for hypocentres directly beneath a site, $\dot{U}_R$ is nearly zero and would be dominated by noise. Statistically it would be expected that 50% of observations of $\frac{\dot{U}_R}{\dot{U}_Z}$for this special case would be less than zero. This means that a desirable feature of the solution for $V_S$as a function of $\frac{\dot{U}_R}{\dot{U}_Z}$and p would be continuity for $\frac{\dot{U}_R}{\dot{U}_Z} \approx 0$. This criterion is met in the formulation for V_S shown in Equation 3.4 (Li et al., 2014). As mentioned in Section 3.2, in its derivation, this formula incorporates the assumption that the sign of the inner radical is always negative. A different formulation of the equation, which preserves the dual roots by a "±", was presented by Kim et al. (2016); Zalachoris et al. (2017); Miao et al. (2018); Kang et al. (2020), but not discussed in detail. Whereas this detail is inconsequential for uniformly good-quality data that has been curated manually, it is important to consider in the context of any automated processing strategies.

Zalachoris et al. (2017) shared some of their code at the outset of this project. In adapting it for the present study, it was evident that unrealistically high values of V_S and V_{S30} would result if the input $\frac{\dot{U}_R}{\dot{U}_Z}$ was negative. To understand the issue better, the Zalachoris et al. (2017) implementation for solving Equation 3.1 for

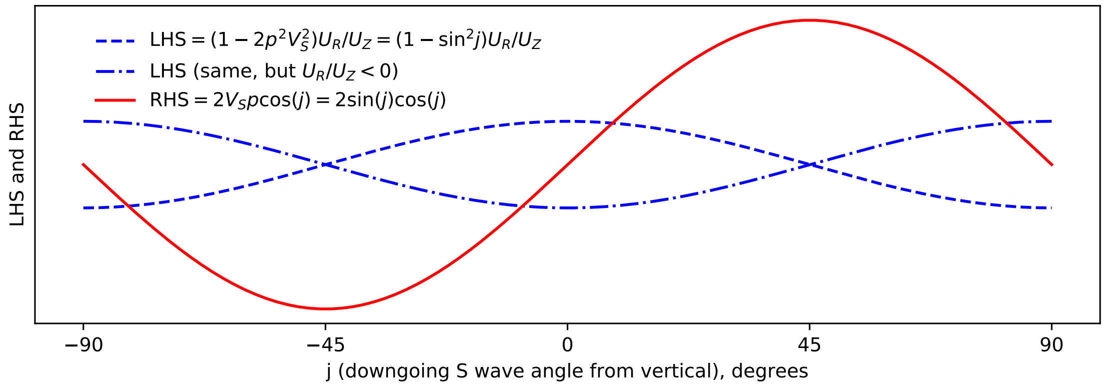

Figure D.1: Left- and right-hand side (LHS, RHS) of Equation 3.1 plotted for two values of $\frac{\dot{U}_R}{\dot{U}_Z}$ of equal magnitude and opposite sign.

V_S is compared against Equation 3.4.

In the Zalachoris et al. (2017) approach, each side of Equation 3.1 was multiplied by the denominator and the identity from Equation 3.3 was substituted to obtain the left- and right-hand side expressions,

$$\begin{aligned} \text{LHS} &= \frac{\dot{U}_R}{\dot{U}_Z}(1-p^2V_S^2) = \frac{\dot{U}_R}{\dot{U}_Z}(1-\sin^2 j) \\ \text{RHS} &= 2V_S p\cos(j). \end{aligned} \tag{D.1}$$

LHS and RHS are plotted with the S-wave refraction angle j as independent variable in Figure D.1. The left hand side is plotted for two values of $\frac{\dot{U}_R}{\dot{U}_Z}$ of equal magnitude and opposite sign. Each location where a blue (LHS) trace crosses the red (RHS) trace is a root with a corresponding value of V_S. (The functional form is of interest, not the specific value of $\frac{\dot{U}_R}{\dot{U}_Z}$, so the vertical axis has no scale).

In the Zalachoris et al. (2017) numerical approach, only a value of $j > 0°$ that minimized the difference between LHS and RHS was allowed; consequently, negative $\frac{\dot{U}_R}{\dot{U}_Z}$ yields values of $j > 45$ deg.

As is seen in Figure D.1, negative values of $\frac{\dot{U}_R}{\dot{U}_Z}$ yield one value of V_S for a (small) negative angle j and another value for a (large) positive j. Since the P-wave method obtains the ray parameter p by assuming the arrival angle i (Figures

3.1-3.4), selecting a negative j is inconsistent with rest of the problem.

The solution given by Li et al. (2014) assumes the case where $0° < j < 45°$ and $\frac{\dot{U}_R}{\dot{U}_Z} > 0$. We discuss the special case of negative ratios here because it can arise as a consequence of baseline drift in noisy records particularly if ground motions are processed in an automated or semi-automated fashion. Even in ideal circumstances (*i.e.*, no appreciable baseline drift and relatively high signal-to-noise ratio [SNR]), it is still possible to compute a negative velocity ratio for ground motions with near-vertical incident P-wave arrivals. This happens if the arriving P wave is near-vertical and therefore the radial component at the moment of vertical arrival is essentially just noise; in this case the probability that $\frac{\dot{U}_R}{\dot{U}_Z} < 0$ approaches 0.5.

In their implementation of the P-wave method, Zalachoris et al. (2017) (pers. comm.) searched for a value of j ($0 < j < 90°$) that minimized the difference in the left and right side of equation 3.1 as shown in Figure D.1. In our explorations of automated and semiautomated pulse-picking, we observed that this approach yields unrealistically high values of V_S for $\frac{\dot{U}_R}{\dot{U}_Z} < 0$, because the root for $j > 45°$ is selected.

For manually selected motions where appropriate judgment is applied to baseline issues, $\frac{\dot{U}_R}{\dot{U}_Z} > 0$ and this caveat is not a concern. But records with $\frac{\dot{U}_R}{\dot{U}_Z} < 0$ should be discarded, whether they are derived from manually or automatically-processed ground motions. $\frac{\dot{U}_R}{\dot{U}_Z} > 0$ is a necessary (though insufficient) indicator of the quality of records and/or their baseline correction for all but highly unusual sites (where the ground or subsurface stratigraphy depart significantly from the horizontal and where the P-wave method is not applicable anyway).

Appendix E

Electronic supplements to the P-wave method study

The complete collection of event-station pairs used in the P-wave method study (Chapter 3) to generate estimates of V_{S30} at strong motion stations is too large to include in PDF format. Since some readers may wish to replicate elements of this study and/or to verify computer codes for similar research, I am hosting the event-station pairs as a text file on my website, Foster (2021a).

The file is formatted with fixed widths for readability within text editors and can be imported by any computer program as whitespace-delimited. The first row of the file contains column headings, and the second row gives units where applicable. These columns are summarised here:

Table E.1: Summary of fixed-width columnar data hosted electronically. Unit abbreviations: metre=m; kilometre=km; second=s.

Column title	Units	Description
stationCode	N/A	Unique alphanumeric station identifier (cross-reference with Table 3.1)
eventID	N/A	Unique earthquake identifier from GeoNet
magnitude	N/A	Moment magnitude
eventTime	UTCDateTime[a]	Event time
depth_km	km	Hypocentre depth as reported by GeoNet FDSN server
epiLat	degrees	Epicentre latitude
epiLon	degrees	Epicentre longitude
log10_SNRae	N/A	Base-10 logarithm of signal-to-noise ratio computed as described in Section 3.3
dist_km	km	Source-to-site distance
d1_m	m	Depth to major velocity contrast, D_1 (Figure 3.3 as obtained from NZVM[b]
d2_m	m	$(1000 \times$ depth_km$) -$ d1_m, *i.e.* D_2 (Figure 3.3)
Vp1_m_s	m/s	Time-averaged P-wave velocity computed vertically along distance D_1 beneath station; V_{P1} in Figure 3.3
Vp2_m_s	m/s	Time-averaged P-wave velocity computed vertically along distance D_2 beneath basement; V_{P2} in Figure 3.3
R1_m	m	R_1 (Figure 3.3)
R2_m	m	R_2 (Figure 3.3)
rayP_s_km	s/km	Ray parameter p (Equation 3.2)
backAz_deg	degrees	Back-azimuth (compass bearing from station to epicentre)
pickArrvTime	UTCDateTime	Timestamp of P-phase arrival as determined by ar_pick (Section 3.3)
ZpulseTime_LBC_V1	UTCDateTime	Timestamp of first pulse peak for vertical component of velocity, automated linear LBC approach (t_{peak}: Section 3.5.2)
ratio_LBC_V1	N/A	$\frac{\dot{U}_R}{\dot{U}_Z}$ ratio at t_{peak}
j_LBC_V1	degrees	Angle j measured from vertical of the reflected S-wave (Figure 3.1)
Vsz_LBC_V1	m/s	V_{SZ} (Sections 3.1, 3.2)
z_LBC_V1	m	z (Section 3.2)
Vs30_LBC_V1	m/s	V_{S30}

[a] UTCDateTime is a timestamp format provided by the ObsPy Python package and readable as date and time in UTC (Coordinated Universal Time).
[b] NZVM does not account for topography; see Thomson et al. (2020)

Bibliography

Abrahamson, N. A. and Youngs, R. (1992). "A stable algorithm for regression analyses using the random effects model." *Bulletin of the Seismological Society of America*, 82(1), 505–510.

Ahdi, S. K., Stewart, J. P., Ancheta, T. D., Kwak, D. Y., and Mitra, D. (2017a). "Development of Vs profile database and proxy-based models for Vs30 prediction in the Pacific Northwest region of North America." *Bulletin of the Seismological Society of America*, 107(4), 1781–1801.

Ahdi, S. K., Stewart, J. P., Kwak, D. Y., Ancheta, T. D., and Mitra, D. (2017b). "Proxy-based Vs30 prediction in Alaska accounting for limited regional data." *PBD-III, Performance Based Design in Geotechnical Earthquake Engineering, Vancouver, British Columbia.*

Ahern, T., Casey, R., Barnes, D., Benson, R., and Knight, T. (2012). *SEED Reference Manual: Standard for the Exchange of Earthquake Data*. International Federation of Digital Seismograph Networks, Incorporated Research Institutions for Seismology, and United States Geological Survey, third edition edition, <http://www.fdsn.org/pdf/SEEDManual_V2.4.pdf> (August).

Akazawa, T. (2004). "A technique for automatic detection of onset time of p-and s-phases in strong motion records." *Proceedings of the 13th World Conference on Earthquake Engineering.*

Aki, K. and Richards, P. G. (2002). *Quantitative seismology*. University Science Books, 2nd edition edition.

Allen, T. I. and Wald, D. J. (2007). "Topographic slope as a proxy for seismic site-conditions (Vs30) and amplification around the globe." *Open-File Report 2007-1357*, United States Geological Survey (USGS), <https://pubs.usgs.gov/of/2007/1357/>.

Allen, T. I. and Wald, D. J. (2009). "On the use of high-resolution topographic data as a proxy for seismic site conditions (Vs30)." *Bulletin of the Seismological Society of America*, 99(2A), 935–943.

Ammon, C. J. (1997). "An overview of receiver-function analysis." Penn State, <http://eqseis.geosc.psu.edu/cammon/HTML/RftnDocs/rftn01.html> (June/July).

Arai, H. and Tokimatsu, K. (2004). "S-Wave Velocity Profiling by Inversion of Microtremor H/V Spectrum." *Bulletin of the Seismological Society of America*, 94(1), 53–63.

Barringer, J., Pairman, D., and McNeill, S. (2002). "Development of a high resolution digital elevation model for New Zealand." *Landcare Research Contract Report LC0102/170*, Landcare Research, <https://lris.scinfo.org.nz/document/9213-analysis-of-dem-accuracy/>.

Bates, D., Mächler, M., Bolker, B., and Walker, S. (2014). "Fitting linear mixed-effects models using lme4." *arXiv preprint arXiv:1406.5823*.

Beyreuther, M., Barsch, R., Krischer, L., Megies, T., Behr, Y., and Wassermann, J. (2010). "Obspy: A python toolbox for seismology." *Seismological Research Letters*, 81(3), 530–533.

Boore, D. M. (2005). "On Pads and Filters: Processing Strong-Motion Data." *Bulletin of the Seismological Society of America*, 95(2), 745–750.

Boore, D. M. and Bommer, J. J. (2005). "Processing of strong-motion accelerograms: needs, options and consequences." *Soil Dynamics and Earthquake Engineering*, 25(2), 93–115.

Boore, D. M., Joyner, W. B., and Fumal, T. E. (1997). "Equations for estimating horizontal response spectra and peak acceleration from western north american earthquakes: A summary of recent work." *Seismological research letters*, 68(1), 128–153.

Borcherdt, R. D. (1994). "Estimates of site-dependent response spectra for design (methodology and justification)." *Earthquake spectra*, 10(4), 617–653.

Castellaro, S., Mulargia, F., and Rossi, P. L. (2008). "Vs30: Proxy for Seismic Amplification?." *Seismological Research Letters*, 79(4), 540–543.

CEN (1994). "Eurocode 8: Design provisions for earthquake resistance of structures." *Report no.*, European Committee for Standardization (CEN).

Cousins, W. J., Perrin, N., McVerry, G., Herreford, R., and Porritt, T. (1996). *Ground conditions at strong-motion recording sites in New Zealand*, Vol. 96. Institute of Geological & Nuclear Sciences Ltd., <http://shop.gns.cri.nz/sr_1996-033-pdf/> 244pp.

Cox, B. and Vantassel, J. (2018). "Dynamic characterization of wellington, new zealand." DesignSafe-CI, <https://doi.org/10.17603/DS24M6J> (11).

Cox, B. R., Wood, C. M., Deschenes, R., and Pearson, M. (2011). "University of Arkansas preliminary data report for: Surface wave testing in Christchurch, New Zealand affected by the New Zealand earthquakes. Work Performed in Conjunction with the NSF RAPID Proposal: Liquefaction and its Effects on Buildings and Lifelines in the February 22, 2011 Christchurch, New Zealand Earthquake.

Cox, B. R., Wood, C. M., and Teague, D. P. (2014). "Synthesis of the utexas1 surface wave dataset blind-analysis study: Inter-analyst dispersion and shear wave velocity uncertainty." *Geo-Congress 2014 Technical Papers: Geo-Characterization and Modeling for Sustainability (GSP 234)*, ASCE (American Society of Civil Engineers), <https://ascelibrary.org/doi/abs/10.1061/9780784413272.083>.

Crotwell, H. P., Owens, T. J., and Ritsema, J. (1999). "The TauP Toolkit: Flexible Seismic Travel-time and Ray-path Utilities." *Seismological Research Letters*, 70(2), 154–160.

D'Agostini, G. (2003). *Bayesian reasoning in data analysis: A critical introduction*. World Scientific.

Deschenes, M. R., Wood, C. M., Wotherspoon, L. M., Bradley, B. A., and Thomson, E. (2018). "Development of deep shear wave velocity profiles in the Canterbury Plains, New Zealand." *Earthquake Spectra*, 34(3), 1065–1089.

Destegul, U., Dellow, G., and Heron, D. (2009). "A ground shaking amplification map for New Zealand." *Bulletin of the New Zealand Society for Earthquake Engineering*, 42(2), 122.

Diggle, P. J. and Ribeiro, Jr, P. J. (2007). *Model-based geostatistics*. Springer Series in Geostatistics. Springer.

Dobry, R., Borcherdt, R., Crouse, C., Idriss, I., Joyner, W., Martin, G. R., Power, M., Rinne, E., and Seed, R. (2000). "New site coefficients and site classification system used in recent building seismic code provisions." *Earthquake spectra*, 16(1), 41–67.

Douglas-Clifford, A. (2017). "Nobody lives here: Uninhabited areas of new zealand." The Map Kiwi, <https://www.andrewdc.co.nz/project/nobody-lives-here-uninhabited-areas-of-new-zealand/> (December).

EPRI (1993). "Guidelines for determining design basis ground motions: Technological report tr-102293." *Report no.*, Electric Power Research Institute.

Farr, T. G., Rosen, P. A., Caro, E., Crippen, R., Duren, R., Hensley, S., Kobrick, M., Paller, M., Rodriguez, E., Roth, L., Seal, D., Shaffer, S., Shimada, J., Umland, J., Werner, M., Oskin, M., Burbank, D., and Alsdorf, D. (2007). "The shuttle radar topography mission." *Reviews of Geophysics*, 45(2).

FEMA (2003). "Nehrp recommended provisions for seismic regulations for new buildings and other structures." *Report no.*, Federal Emergency Management Agency.

Foster, K. (2021a). "Electronic Supplement to *P*-wave Method Study, <https://fostergeotech.com/Pwave/eventStationPairs/>.

Foster, K. (2021b). "New Zealand V_{S30} model, <https://fostergeotech.com/Vs30map/>.

Foster, K. M., Bradley, B. A., McGann, C. R., and Wotherspoon, L. M. (2019). "A vs30 map for new zealand based on geologic and terrain proxy variables and field measurements." *Earthquake Spectra*, 35(4), 1865–1897.

Gelman, A., Carlin, J. B., Stern, H. S., Dunson, D. B., Vehtari, A., and Rubin, D. B. (2014). *Bayesian data analysis*. CRC Press, Boca Raton, FL, 3rd edition edition.

GeoNet (2020). "Stream naming conventions." GeoNet, <https://www.geonet.org.nz/data/supplementary/channels>.

GNS Science (2016). "1:250000 geological map of New Zealand (QMAP), <https://www.gns.cri.nz/Home/Our-Science/Earth-Science/Regional-Geology/Geological-Maps/1-250-000-Geological-Map-of-New-Zealand-QMAP>. Last accessed October 2018.

Horn, B. K. (1981). "Hill shading and the reflectance map." *Proceedings of the IEEE*, 69(1), 14–47.

Hosseini, M., Somerville, P., Skarlatoudis, A., Thio, H. K., and Bayless, J. (2016). "Constraining shallow subsurface s wave velocities with the initial portion of local p waves recorded at multiple seismic networks including anss, and earthscope transportable array in the ceus." *US Geol. Surv. Final Tech. Rept. Award Number G14AP00110*.

Iwahashi, J. and Pike, R. J. (2007). "Automated classifications of topography from DEMs by an unsupervised nested-means algorithm and a three-part geometric signature." *Geomorphology*, 86(3-4), 409–440.

Jayaram, N. and Baker, J. W. (2009). "Correlation model for spatially distributed ground-motion intensities." *Earthquake Engineering & Structural Dynamics*, 38(15), 1687–1708.

Kaiser, A., Van Houtte, C., Perrin, N., Wotherspoon, L., and McVerry, G. (2017). "Site characterisation of GeoNet stations for the New Zealand strong motion database." *Bull. New Zeal. Soc. Earthq. Eng.*, 50(1), 39–49.

Kang, S., Kim, B., Park, H.-J., and Lee, J. (2020). "Automated procedure for estimating vs30 utilizing p-wave seismograms and its application to japan." *Engineering Geology*, 264, 105388.

Kennett, B. L. N., Engdahl, E. R., and Buland, R. (1995). "Constraints on seismic velocities in the earth from traveltimes." *Geophysical Journal International*, 122(1), 108–124.

Kim, B., Hashash, Y. M. A., Rathje, E. M., Stewart, J. P., Ni, S., Somerville, P. G., Kottke, A. R., Silva, W. J., and Campbell, K. W. (2016). "Subsurface shear wave velocity characterization using p-wave seismograms in central and eastern north america." *Earthquake Spectra*, 32(1), 143–169.

King, A., Bull, D., Clifton, C., Dowrick, D., Jury, R., McVerry, G., Moss, P., and O'Leary, A. (2004). "NZS1170.5: Structural design actions - Part 5: Earthquake actions - New Zealand." Technical Committee BD-006-04-11, <https://shop.standards.govt.nz/catalog/1170.5%3A2004%28NZS%29/view>.

Kwok, O. L. A., Stewart, J. P., Kwak, D. Y., and Sun, P.-L. (2018). "Taiwan-specific model for vs30 prediction considering between-proxy correlations." *Earthquake Spectra*.

Landcare Research New Zealand (2010). "New Zealand digital elevation model 25-metre, <https://lris.scinfo.org.nz/data/category/elevation/>.

Lee, C.-T. and Tsai, B.-R. (2008). "Mapping vs30 in taiwan.." *Terrestrial, Atmospheric & Oceanic Sciences*, 19(6).

Lee, E.-J., Chen, P., Jordan, T. H., Maechling, P. B., Denolle, M. A. M., and Beroza, G. C. (2014). "Full-3-d tomography for crustal structure in southern california based on the scattering-integral and the adjoint-wavefield methods." *Journal of Geophysical Research: Solid Earth*, 119(8), 6421–6451.

Lee, V. W. and Trifunac, M. D. (2010). "Should average shear-wave velocity in the top 30 m of soil be used to describe seismic amplification?." *Soil Dynamics and Earthquake Engineering*, 30(11), 1250–1258.

Lermo, J. and Chávez-García, F. J. (1993). "Site effect evaluation using spectral ratios with only one station." *Bulletin of the Seismological Society of America*, 83(5), 1574–1594.

Li, Z., Ni, S., and Somerville, P. (2014). "Resolving shallow shear-wave velocity structure beneath station cbn by waveform modeling of the mw 5.8 mineral, virginia, earthquake sequence." *Bulletin of the Seismological Society of America*, 104(2), 944–952.

Louie, J. (2001). "Faster, better shear wave velocity to 100 meters depth from refraction microtremor arrays." *Bulletin of the Seismological Society of America*, 91(2), 347–364.

McElreath, R. (2015). *Statistical Rethinking: A Bayesian Course with Examples in R and Stan*. CRC Press, Boca Raton, FL.

McGann, C., Bradley, B., Taylor, M., Wotherspoon, L., and Cubrinovski, M. (2015). "Development of an empirical correlation for predicting shear wave velocity of Christchurch soils from cone penetration test data." *Soil Dynamics and Earthquake Engineering*, 75, 66–75.

McGann, C. R., Bradley, B. A., and Cubrinovski, M. (2017). "Development of regional V_{s30} model and typical V_s profiles for Christchurch, New Zealand from CPT data and region-specific CPT-V_s correlation." *Soil Dynamics and Earthquake Engineering*, 95, 48–60.

Miao, Y., Shi, Y., and Wang, S.-Y. (2018). "Estimating near-surface shear wave velocity using the p-wave seismograms method in japan." *Earthquake Spectra*, 34(4), 1955–1971.

Moss, R. E. S. (2008). "Quantifying measurement uncertainty of thirty-meter shear-wave velocity." *Bulletin of the Seismological Society of America*, 98(3), 1399–1411.

Nakamura, Y. (1989). "A method for dynamic characteristics estimation of subsurface using microtremor on the ground surface." *Railway Technical Research Institute, Quarterly Reports*, 30(1).

Nazarian, S. and Stokoe II, K. (1984). "In-situ shear wave velocities from spectral analysis of surface wave tests." *Proc. 8th World Conference on Earthquake Engineering*, San Franciso, CA, 31–38.

Ni, S., Li, Z., and Somerville, P. (2014). "Estimating subsurface shear velocity with radial to vertical ratio of local p waves." *Seismological Research Letters*, 85(1), 82–90.

NZ Standards Association (1992). "New Zealand Standard NZS4203: Code of practice for general structural design and design loadings for buildings." NZ Standards Association, Wellington.

Okada, H. (2003). *The Microtremor Survey Method.* (K. Suto, trans.): SEG Geophysical Monograph Series No. 12, Society of Exploration Geophysicists.

Park, C. and Miller, R. (2008). "Roadside passive multichannel analysis of surface waves (MASW)." *Journal of Environmental and Engineering Geophysics*, 13(1), 1–13.

Park, C., Miller, R., and Xia, J. (1999). "Multichannel analysis of surface waves." *Geophysics*, 64(3), 800–880.

Park, D. and Hashash, Y. M. (2004). "Probabilistic seismic hazard analysis with nonlinear site effects in the mississippi embayment." *Proceedings of the 13th world conference on earthquake engineering, Vancouver, Paper*, number 1549.

Parker, G. A., Harmon, J. A., Stewart, J. P., Hashash, Y. M., Kottke, A. R., Rathje, E. M., Silva, W. J., and Campbell, K. W. (2017). "Proxy-based Vs30 estimation in central and eastern North America." *Bulletin of the Seismological Society of America*, 107(1), 117–131.

Pebesma, E. J. (2014). "Gstat user's manual (version 2.5.1), <http://www.gstat.org/gstat.pdf> (April).

Perrin, N., Heron, D., Kaiser, A., and Van Houtte, C. (2015). "Vs30 and NZS 1170.5 site class maps of New Zealand." *2015 NZSEE Conference*, New Zealand Society for Earthquake Engineering, 10–12, <http://www.nzsee.org.nz/db/2015/Papers/O-07_Perrin.pdf>.

Robertson, P. K., Campanella, R. G., Gillespie, D., and Rice, A. (1986). "Seismic cpt to measure in situ shear wave velocity." *Journal of Geotechnical Engineering*, 112(8), 791–803.

Shearer, P. M. (2019). *Introduction to seismology*. Cambridge university press.

Steidl, J. H. (2000). "Site response in southern california for probabilistic seismic hazard analysis." *Bulletin of the Seismological Society of America*, 90(6B), S149–S169.

Teague, D., Cox, B., Bradley, B., and Wotherspoon, L. (2018). "Development of deep shear wave velocity profiles with estimates of uncertainty in the complex inter-bedded geology of Christchurch, New Zealand." *Earthquake Spectra*, 34(2), 639–672.

Thompson, E. and Wald, D. (2012). "Developing Vs30 site-condition maps by combining observations with geologic and topographic constraints." *Proc. 15th World Conf. on Earthq. Eng., Lisbon, Portugal*, 24–28, <http://www.iitk.ac.in/nicee/wcee/article/WCEE2012_0953.pdf>.

Thompson, E. M., Wald, D. J., and Worden, C. B. (2014). "A Vs30 map for California with geologic and topographic constraints." *Bulletin of the Seismological Society of America*, 104(5), 2313–2321.

Thomson, E. M., Bradley, B. A., and Lee, R. L. (2020). "Methodology and computational implementation of a new zealand velocity model (nzvm2.0) for broadband ground motion simulation." *New Zealand Journal of Geology and Geophysics*, 63(1), 110–127.

United States Geological Survey (USGS) (2012). "Notes on the processing of digitally recorded data." United States Geological Survey (USGS) National Strong Motion Project, <https://escweb.wr.usgs.gov/nsmp-data/processing.html#notes> (February).

Van Houtte, C., Ktenidou, O.-J., Larkin, T., and Holden, C. (2014). "Hard-site κ_0 (kappa) calculations for Christchurch, New Zealand, and comparison with local ground-motion prediction models." *Bulletin of the Seismological Society of America*, 104(4), 1899–1913.

Vilanova, S. P., Narciso, J., Carvalho, J. P., Lopes, I., Quinta-Ferreira, M., Pinto, C. C., Moura, R., Borges, J., and Nemser, E. S. (2018). "Developing a geologically based vs 30 site-condition model for portugal: Methodology and assessment of the performance of proxies." *Bulletin of the Seismological Society of America*, 108(1), 322–337.

Wald, D. J., McWhirter, L., Thompson, E., and Hering, A. S. (2011). "A new strategy for developing vs30 maps." *Proc. 4th Int. Effects of Surface Geology on Seismic Motion Symposium.*

Wills, C. and Clahan, K. (2006). "Developing a map of geologically defined site-condition categories for California." *Bulletin of the Seismological Society of America*, 96(4A), 1483–1501.

Wills, C. and Gutierrez, C. (2009). "Investigation of geographic rules for improving site-conditions mapping." *Digital Mapping Techniques '08—Workshop Proceedings U.S. Geological Survey Open-File Report 2009–1298*, U.S. Geological Survey, 205–216, <http://pubs.usgs.gov/of/2009/1298/>.

Wills, C. J., Petersen, M., Bryant, W. A., Reichle, M., Saucedo, G. J., Tan, S., Taylor, G., and Treiman, J. (2000). "A Site-Conditions Map for California Based on Geology and Shear-Wave Velocity." *Bulletin of the Seismological Society of America*, 90(6B), S187–S208.

Wood, C. M., Cox, B. R., Green, R. A., Wotherspoon, L. M., Bradley, B. A., and Cubrinovski, M. (2017). "Vs-based evaluation of select liquefaction case histories from the 2010-2011 Canterbury earthquake sequence." *Journal of Geotechnical and Geoenvironmental Engineering*, 143(9), 04017066.

Wood, C. M., Cox, B. R., Wotherspoon, L. M., and Green, R. A. (2011). "Dynamic site characterization of Christchurch strong motion stations." *Bulletin of the New Zealand Society for Earthquake Engineering*, 44(4), 195–204.

Woods, R. (1978). "Measurement of dynamic soil properties, state of the art report." *Proc. ASCE Specialty Conference on Earthquake Engineering & Soil Dynamics*, Vol. 1, California Institute of Technology, Pasadena, USA, 91–178.

Worden, C. B., Thompson, E. M., Baker, J. W., Bradley, B. A., Luco, N., and Wald, D. J. (2018). "Spatial and spectral interpolation of ground-motion intensity measure observations." *Bulletin of the Seismological Society of America*, 108(2), 866–875.

Wotherspoon, L., Bradley, B., Thomson, E., Wood, C., Deschenes, M., and Cox, B. (2016). "Dynamic site characterisation of Canterbury strong motion stations using active and passive surface wave testing - version 1.0 - june 2016." *Earthquake Commission Report Project No. 14/663*, University of Auckland.

Wotherspoon, L., Orense, R., Bradley, B., Cox, B., Wood, C., and Green, R. (2013). "Geotechnical characterization of Christchurch strong motion stations - version 1.0 - september 2013." *Earthquake Commision Report Project No. 12/629*, University of Auckland, Faculty of Engineering.

Yong, A. (2016). "Comparison of measured and proxy-based Vs30 values in California." *Earthquake Spectra*, 32(1), 171–192.

Yong, A., Hough, S. E., Iwahashi, J., and Braverman, A. (2012). "A terrain-based site-conditions map of California with implications for the contiguous United States." *Bulletin of the Seismological Society of America*, 102(1), 114–128.

Zalachoris, G., Rathje, E. M., and Paine, J. G. (2017). "Vs30 characterization of texas, oklahoma, and kansas using the p-wave seismogram method." *Earthquake Spectra*, 33(3), 943–961.